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THE ESTIMATES OF THE NAVY DEPARTMENT, to be submitted to the next Congress, calls for $82,426,030; but will not call for any new armored vessels. The chief items are, pay of the navy, $17,106,099; Bureau of Navigation, $1,157,125; Bureau of Ordnance, $2,761,007; Bureau of Equipment, $6,018,602; Bureau of Yards and Docks, $758,903. Under "public works" come Bureau of Yards and Docks, $5,814,440; Naval Academy, $1,000,000; Bureau of Supplies and Accounts, $3,853,972; Bureau of Construction and Repairs, $8,367,024; Bureau of Steam Engineering, $4,007,900. Under Increase of Navy come, construction and machinery, $15,025,632; armor and armament, $10,000,000, etc.

BIDS FOR THE 16,000-TON BATTLESHIP "LOUISiana" were opened at the Navy Department on Oct. 1. The sister ship, the "Connecticut," is to be built at the Brooklyn Navy Yard. Five shipbuilding firms submitted bids as follows: Union Iron Works, San Francisco, $4,150,000, or with the 4% deduction permitted for Pacific coast work, $3,984,000, to be built in 42 months; Newport News Co., $3,990,000, 41 months; New York Shipbuilding Co., Camden, N. J., $4,040,000, 40 months; Fore River Ship & Engine Building Co., Quincy, Mass., $4,087,000, 42 months; Wm. Cramp & Sons, Philadelphia, $4,114,000, 42 months.

A BLAST FURNACE AT IRONDALE, WASH., has just resumed operations after being many years out of blast. It was built in 1877 and was the first blast furnace on the Pacific coast. The ore is obtained from Texada Island, B. C., and the coke from the Fairhaven mine in Skagit county, Wash.

IMPORTS OF IRON AND STEEL, says the U. S. Bureau of Statistics, have almost doubled in the last year. For the eight months ending in August the importations of iron and steel manufactures were $11,000,000 greater in value than for the corresponding period of last year; while the exports of the same class of manufactures are nearly $5,000,000 less, and $21,000,000 less than in this period in 1900. For the month of August, 1902, these imports aggregated $4,374,473, as against $2,096,000 for August, 1901. Pig iron alone this year figured at $1,407,393, as compared with $147,557 in 1901; and ingots, blooms, slabs and billets figure respectively at $948,608 and $84,213 in 1902 and 1901. Iron ore remained practically the same; and tin and terne plates decreased from $570,222 in August, 1901, to $188,842 in August, 1902. In the exports, steel rails fell from $6,715,113 in 1901, to $1,664,422 in 1902, for the eight months in question.

THE ELMORE PROCESS OF ORE CONCENTRATION, by the use of mineral oil, is being introduced into British Columbia by the Canadian Ore Concentration Co., Ltd., of London, England. As described by Mr. G. A. Ohren, U. S. Consular Agent at Rossland, B. C., the ore is pulverized, mixed with water to a freely flowing pulp, and then flows directly from the mill to the open end of a horizontal rotating drum provided inside with spiral blades for lifting the pulp. With this pulp is admitted a small quantity of thick, sticky oil, known as "summer drak oil," from the Pennsylvania oil regions; this oil picks up and holds the suspended mineral, but seems to have no affinity for the rock particles in the same solution. This oil and pulp is discharged from the drum into a pointed box, in which the tailings settle down and pass off with the water at the bottom, while the oil floats and carries with it practically all of the mineral. The oil and mineral then enter a centrifugal machine which separates them. Tests on 250 tons of ore, at the plant at Gladsir Mine, gave a recovery of 90% of mineral by oil, as against 40% by water used with the latest "Frue Vanners" process. A plant of 100 tons capacity per day costs $9,000. British Columbian ore containing 2.2% of copper showed by water concentration a loss of 30 to 58.6%, due to float minerals; by the oil process this loss was reduced to 1 to 7%, practically the whole of the copper being saved.

THE COAL PULVERIZING PLANT at the new Riverside pumping station of the Indianapolis Water Co., noted in our issue of Sept. 18, has two mills. The first is a ball mill, in which the coal is pulverized by steel balls enclosed in the revolving shell; the product from this is conveyed to a tube mill, consisting of a horizontal cylinder partially filled with extremely hard pebbles. This reduces the coal to an impalpable powder, which is blown into the boiler furnace through specially designed nozzles by means of jets of compressed air.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between two freight trains on the Baltimore & Ohio R. R., near Cornwallis, W. Va., on Oct. 3. The wreck, which was due to a misunderstanding of orders on the part of one of the train crews, occurred in a tunnel, and at full speed. At least five persons were killed outright and several injured.—Several accidents are reported in which one or two persons were killed; a few of these are given here: Two switching trains collided on the Philadelphia, Wilmington & Baltimore R. R., at Washington, D. C., on Oct. 3, and two train hands were killed. A passenger train ran into a switching engine on the Boston & Maine R. R., near Greenfield, Mass., on Oct. 3, killing two men of the train crews. Two passenger trains collided head on near Columbus, Mont., on the Northern Pacific Ry., Oct. 4; a fireman and a mail clerk were killed.

A SERIES OF DAM, RESERVOIR AND TANK FAILures has occurred recently. Since the Utica failure, described briefly in our issues of Sept. 18 and 25, and more fully elsewhere in this issue, the water-works reservoir at Camden, N. J., has lost a portion of one embankment; the dam of the Stanton Water Power Co., at Stanton, Neb., has been "carried out for the second time, about six hours after its completion," and the new dam of the Caro Light & Power Co., of Caro, Mich., has developed "some flaw in construction." Both these dams were still in the hands of the respective contractors. A 45,000-gallon wooden water tank at Provincetown, Mass., belonging to the New York, New Haven & Hartford Railroad Co., is reported as having failed on Oct. 2, through the bursting of its hoops. A 2,000-gallon tank on the roof of the Kroeger Piano Factory, at Stamford, Conn., also went to pieces on Oct. 2, due, it is thought, to the same cause. An account of the Camden reservoir failure is given elsewhere in this issue. In a later issue we shall describe the failure of a wooden water-works tank at Madison, Neb., which occurred some weeks ago.

THE UPPER TALLASSEE DAM across the Tallapoosa River, above Tallassee, Ala., to develop electric light and power for use in Montgomery, 29 miles distant, has been actually or practically completed. The dam, which was described in our issue of Dec. 5, 1901, was made notable by damage to the closure masonry, due to a flood the latter part of the same month. A number of letters relating to the construction of the dam and the accident that befell it appeared in our columns early in the current year.

THE PATERSON SEWAGE POLLUTION SUITS may now be tried on their merits. By means of these suits riparian owners of land, or lessees of land or water power on the Passaic River above the ebb and flow of the tide, are seeking either to enjoin Paterson from discharging sewage into the river or else to compel the city to compensate them for damages therefor. Vice-Chancellor Stevens has overruled the demurrers entered by the city against the case, holding that all the complainants have rights in the matter which may properly be adjusted before the courts.

PRELIMINARY OR ROUGHING FILTERS at the lower Roxborough filter plant, Philadelphia, are to be installed if present plans are carried through. Bids for such filters were invited on Sept. 23. The Maignen Filtration Co., of Philadelphia, was the only bidder, offering to install a 12,000,000-gallon plant working at the rate of 1,377 gallons per sq. ft. per day, or 60,000,000 gallons per acre, for $49,800, or one operating at a 2,066-gallon rate, or 90,000,000 gallons per day, for $60,500. From the specifications for this work we extract the following particulars: The preliminary filters must have a sufficient reserve capacity to treat 12,000,000 gallons of subsided Schuylkill River water per day, as drawn from a 13,000,000-gallon subsiding reservoir. The rough-filtered water must flow by gravity to the ordinary slow-sand filters already provided. The filter house and foundations for the rough filters will be furnished by the city. No coagulants or other chemicals will be allowed. The bidder was required to guarantee the reduction in turbidity effected by his proposed plant, and also the cost of maintenance and operation, including in the latter all wash water at the rate of $15 per 1,000,000 gallons of water thus used and wasted. The contractor must also operate the rough filters at his own expense for 365 days of continuous service, during which the filters will be tested by the city. The reduction of turbidity is to be guaranteed not to fall below a stipulated percentage for 90% of the full year of test, and not to fall below other-named percentages for the first and the second 5% of the remainder of the year. Each unit of the filter system is to be provided with a water meter, self-reading head gage and regulating valve. In case the filters, during the year of test, fail to comply with the guarantee, the city may either reject them, or deduct from the contract price 1% for each 1% of failure to reduce turbidity, or to be operated within the price named. If there is failure as to both guarantees or of the turbidity guarantee alone in excess of 10%, the city will not accept the plant. The method of computing the turbidity reductions, for the above purpose, is to be as follows:

The reduction of turbidity for this purpose will be taken as the sum of the products of the percentages of time into the maximum allowable turbidity stated. Let x, thus represent the maximum allowable turbidity for 90% of the time, x_1, the maximum allowable turbidity for the next 5% of the time, and x_2, the maximum allowable turbidity for the remaining 5% of the time expressed in the guarantee. Then the combined reduction of turbidity for estimating reduction on the contract price will be:

$$R = 90x + 5x_1 + 5x_2.$$

THE EXPOSITION OF COMMERCE AND HYGIENE, which was to have opened at Athens, Greece, this month, has been postponed to April, 1903, in order to afford more opportunity for Americans to enter the exposition.

TAR FOR LAYING DUST on macadamized roads has been tried experimentally abroad, according to a consular report by Mr. H. H. Morgan, dated Lucerne, Sept. 4, 1902. The report first mentions experiments made by Dr. Guglielminetti, of Monte Carlo, and then gives an extract from an unnamed continental paper relating to experiments at Champigny. The apparatus for spreading the tar was devised by M. Andouin, Chief Engineer of the chemical department of the Compagnie Parisienne du Gaz. One device consisted of a hand-sprinkling can, "with a fan-shaped nozzle, pierced by two rows of orifices." The other device included a 50-gallon tank, "heated by a traveling furnace, and operated in the same manner as an ordinary sprinkling tank." The day before applying the tar, the road "should be thoroughly washed and brushed," so as to lay "bare the macadam," and give an opportunity for the disappearance of "all traces of humidity." The hot tar should be spread "in a thin layer." At Champigny, "when the tar commenced to cool, fine sand was scattered over the section treated," and "orders were then given that the road should be closed to traffic for a few days." At Geneva, after tar had been applied for six weeks, it had not softened "in spite of the very hot weather"; frequent rain storms had done no harm and the road was not slippery. At $9.65 per ton, the tar is said to cost about 1 ct. per sq. yd. of road treated.

ROLLED STEEL PLATES for worn steam road roller wheels are described in the London "Surveyor" for Sept. 12. The Oxfordshire Steam Ploughing Co., of Cowley, Oxford, has been plating worn wheels in this way for three years, and has a special plant for the purpose. Plates 1¼ ins. thick, in segments, are used. On the basis of 1-24-in. wear in 100 days, and allowing the plates to be good for half their thickness, the cost of renewals for the wheel surfaces of 22,240-lb. rollers would be about 12 cts. per day per roller. Just how the plates are applied is not stated, but it is said that cast-iron plates proved a failure, being useless except when "put on in very thick section," while as soon as worn down to a proper thickness "they broke or became loose." The manufacturers named now supply, when desired, new rollers provided with steel-plated wheels.

A NEW SIGNAL SERVICE SCHOOL will be established by the government at Blue Ridge, London Co., Va., and 60 acres have been bought there for this purpose. Temporary buildings will be at once erected and instruments installed. The school is located at an elevation of 2,900 ft. above Washington, D. C., 60 miles distant, and signaling will be carried on between these points.

THE AURORA, ELGIN & CHICAGO THIRD-RAIL ELECTRIC INTERURBAN RAILWAY.

Among the numerous interurban electric railways now in operation or under construction, one of the most important and most interesting is the Aurora, Elgin & Chicago Ry., which has recently been completed, and which was opened for traffic on Aug. 25. The line is designed for high-speed service, has a double track for a large portion of its length, and is operated entirely on the third-rail system. This system was adopted as being an improvement upon the trolley system for railways of this class, being better adapted for high-speed service, and more economical in maintenance than the ordinary overhead construction.

As railways of this class have developed from the electric street railway there is still a general tendency to speak of them as street railways, even when built upon private right of way. As a matter of fact, they may be fairly considered as forming a special class of themselves, and the line in question conforms very closely to ordinary steam railway practice in its location and construction. The railway is built entirely upon its own right of way, and its construction has involved some heavy cuts and embankments to

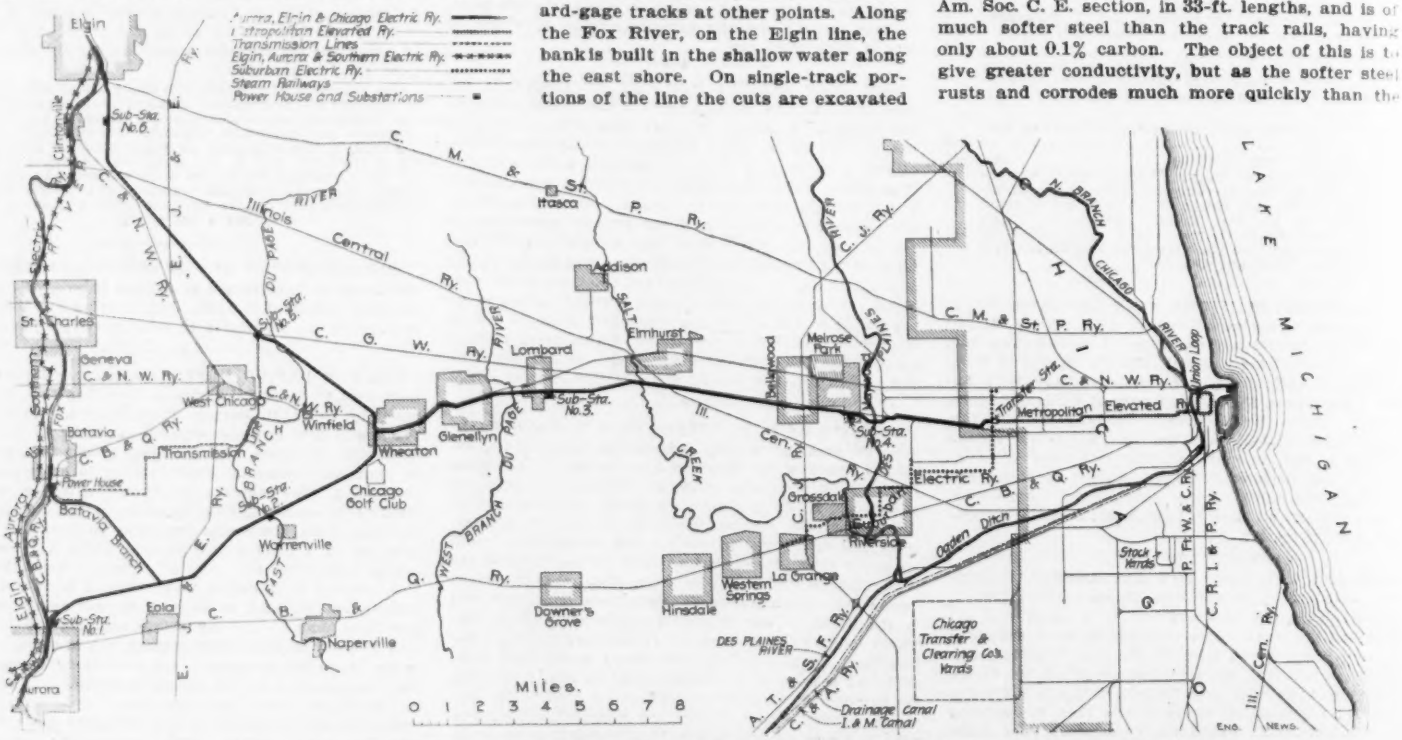


FIG. 1. MAP OF THE AURORA, ELGIN & CHICAGO RY. CO.'S THIRD-RAIL ELECTRIC INTERURBAN RY.
Charles Jones, Chief Engineer, Wheaton, Ill.

give the easy grades and curvature demanded by a high-speed line. It is of substantial construction, with steel and concrete structures throughout and a heavy track.

The road will have about 82 miles of main line, of which 21½ miles are double track. The distance from Chicago (52d Ave. and Harrison St.) to Wheaton and Aurora is 33.3 miles; the line from Wheaton to Elgin, 16.5 miles; and the Batavia branch, 6 miles. It will serve a population of about 80,000 outside of Chicago. The same interests own the Elgin, Aurora & Southern Traction Co., with 70 miles of track. Of this length, 37 miles comprise the interurban line between Carpentersville and Yorkville, while the balance consists of city or street lines in Aurora and Elgin. Fig. 1 is a map of the railway.

The line will be operated mainly by trains instead of single cars, the multiple unit system being adopted, in which each car has its own motive power, but all the motors are controlled from the head of the train. There will also be trail cars without motors, to be attached to motor cars for two-car trains.

There are trains in both directions every half hour. At present the time allowed for the run between Aurora and Chicago or Elgin and Chicago is 1 hr. 15 mins., but this will be reduced to 45 minutes as soon as everything is in good running order. This will give an average speed of about 45 miles an hour from start to finish, which will necessitate actual running speeds of 50 to 60 miles per hour. The traffic is handled by the telephone train dispatching system, the head dispatcher at Wheaton communicating with the men at the substations, or with the conductors, who report at these stations. The cars are equipped with portable telephones, and means for connecting these with the telephone wires are provided in small iron cabins at all turnouts and crossovers; while at intervals along the road the wires are brought down the poles so that the telephones can be attached. Block signals may be introduced later.

ROADWAY AND TRACK.

The width of right of way is mainly 66 and 100 ft. The lighter grading was done with plows and scrapers, while the heavier work was done with steam shovels and locomotives and side dump cars, temporary trestles being used for building the center of the large banks, which were then widened out as required. Narrow-gage construction tracks were used at some points, and standard-gage tracks at other points. Along the Fox River, on the Elgin line, the bank is built in the shallow water along the east shore. On single-track portions of the line the cuts are excavated to a width sufficient for double track. The maximum grade is one of 1.8%, a mile in length, entering the Fox River valley, but on the rest of the system the aim has been to limit all grades to 1%. The ordinary curves connecting long tangents are of 1° and 2°, and the maximum on high-speed portions of the line is 4°. Near the Chicago terminal two reverse curves of 16° (with a short tangent between) are required to avoid interference with cemetery property, but as these are between two railway grade crossings (at which all cars must stop) they do not affect the question of speed. The superelevation on curves is about 1 in. per degree, with a maximum elevation of 5 ins.

The width of roadbed is 16 ft. for single track (13 ft. over toe of ballast), and 28 ft. for double track (26 ft. over ballast), as shown in Fig. 2. The track is laid with 80-lb. rails of the Am. Soc. C. E. section, 60 ft. in length, and having about 0.6% of carbon. They are laid with broken joints and spliced with angle bars and four 1-in. bolts with lock nuts. Bolts of this size are rarely used on steam railway track, except for frogs. In tracklaying, the 60-ft. rails are unloaded from the cars by hand, being run out over two timber horses or "dollies" placed on the subgrade, ahead of the car. The first of these is a little [illegible] than the floor of the car, and the second is [illegible] siderably lower, and each has at the top a [illegible] roller. On double track, the tracks are 13 [illegible] to c., and are connected by crossovers at inter[illegible] of three or four miles. On single track there [illegible] passing sidings at similar intervals; these sidi[illegible] are 700 ft. to a mile in length, long sidings b[illegible] provided at curves so as to provide practic[illegible] double track, and thus give greater safety [illegible] high-speed running at some points. There a[illegible] 32 oak and cedar ties to a 60-ft. rail, and th[illegible] ballast is of gravel, with a depth of 9 ins. und[illegible] the ties. The rail joints are fitted with the el[illegible] tric bonds of the Protected Rail Co., of Phil[illegible] delphia, Pa., or with the 12-in. "United State[illegible] rail bond of the American Steel & Wire Co., o[illegible] Chicago. The rails are cross-bonded at interval[illegible] of 500 ft. The switches are of the split pattern[illegible] with 15-ft. reinforced switch rails; and No. 10[illegible] spring-rail frogs are used for main track turn[illegible] outs. High switchstands are used, except in yards[illegible] The switch and crossing work was built by th[illegible] Morden Frog & Crossing Works and the Ajax[illegible] Forge Co., both of Chicago.

The conductor or third rail is of the 100-lb. Am. Soc. C. E. section, in 33-ft. lengths, and is of much softer steel than the track rails, having only about 0.1% carbon. The object of this is to give greater conductivity, but as the softer steel rusts and corrodes much more quickly than the harder steel, the third rail is painted with a cheap asphalt paint thinned with gasoline. This rail is carried by insulating supports on the ties (every fifth tie being of extra length), as shown in Fig. 2. These supports are blocks of wood boiled in paraffine. The joints of the third rail are spliced with two-bolt malleable cast-iron splice bars, and are fitted with the Protected Rail Co.'s rail bonds of U-shape. The holes in the rail flanges for attaching the bonds were made after the rails were laid; some were punched by a portable hydraulic press, and others were drilled (either by hand or by a gasoline machine mounted on a hand-car). At grade crossings, the third rail is cut; the last rail is dropped 2 ins. in its length and has its end fitted with an incline 24 ins. long to raise the contact-shoes of the cars into place. At switches a "drop rail" is used, as shown in Fig. 3, so as to clear the shoes of cars on the turnout, the sides of which would otherwise strike the side of the rail. The ends of the rails are connected by cables laid under the crossings. Single cars will drift over the crossings, but trains (and even single cars at short crossings) will have the front shoe again in contact before the rear shoe has left the rail.

All highway grade crossings are planked and

fitted with cattle-guards of vitrified clay blocks, made by the Climax Stock Guard Co., of Chicago, and bell or other warning signals may be installed later at important highways. There are only four railway grade crossings, one of which is a crossing of an electric line operated by only one car per hour. The other three (one of which comprises three parallel steam roads) are protected by interlocking plants.

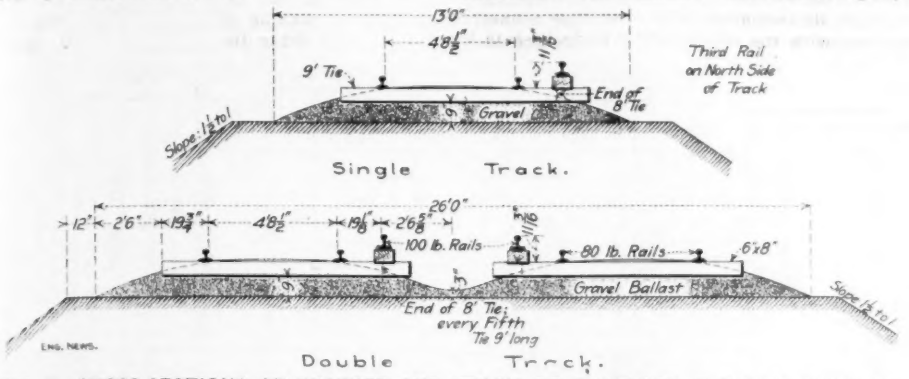


FIG. 2. CROSS-SECTIONS OF ROADBED AND TRACK OF THIRD-RAIL ELECTRIC RAILWAY.

BRIDGES.

All steel bridges were designed in accordance with Cooper's specifications, with his Class E-40 loading. Mr. W. M. Hughes, M. Am. Soc. C. E., of Chicago, was Consulting Engineer for the bridge work, and all these structures were built by the King Bridge Co., of Cleveland, O. There is only one truss bridge, crossing the Chicago & Northwestern Ry., at Elgin, on a skew. This has a span of 158 ft. 7 ins., with shallow floor construction, and one end rests on columns, connecting with a steel viaduct 363 ft. long.

All the other steel bridges are of plate girder construction. There are two 100-ft. spans (arranged for three tracks) over the Des Plaines River, and a double-track deck bridge of 70 ft. span over the East branch of the Du Page River. At Warrenville there is an 89-ft. span over the West branch of the Du Page River with a 24-ft. cattle-pass and culvert at one end. Besides the Chicago & Northwestern Ry., already noted, the line passes over two other railways, by girder spans of 69 and 80 ft., respectively. It also passes under five railways, which are carried by girder spans of 36 to 60 ft. There are 12 plate-girder bridges carrying the line over streets and roads, and four carrying roads over the railway. The latter have 45-ft. main spans (to allow for future double tracking), with 20-ft. I-beam approach spans. Besides these there are a number of small openings spanned by I-beams with concrete filling. The steel bridges have open floors, but with closely-spaced ties and a substantial floor system. All piers and abutments are of concrete.

There are four concrete bridges, besides a number of concrete culverts and cattle-passes. The Salt Creek bridge, Fig. 4, has two 35-ft. arches (with a rise of 1 in 6); the Poplar Creek bridge at Elgin has one 30-ft. arch, and another bridge over the West branch of the Du Page River, and on the Elgin branch, has two 30-ft. arches (with a rise of 1 in 10). The smaller structures have arches of 10, 12 and 15-ft. span, and one of these has two 15-ft. spans. Old 60-lb. rails are laid in all the arches, except those of 12 and 15-ft. span. They are placed about 36 ins. apart, near the center line of the arch ring, and extend into the haunches. The standard cattle-pass, Fig. 5, is 10 ft. wide and 7 ft. high, with 10-in. I-beams 14 ins. c. to c., embedded in concrete. One of these, with two openings, is shown in Fig. 6. The beams are embedded in concrete, but are figured to carry the entire load unaided by the concrete. This beam construction enables much lighter abutment walls to be used than for an arch culvert, as there is no thrust to be resisted. The cost is also about 20% less than for an open-floor bridge with I-beams on concrete abutments, since the latter would require heavier abutments than where the beams are embedded in the concrete.

In one cattle-pass, Fig. 7, concrete jack arches are turned between the I-beams, but instead of the ordinary removable wooden centering, arches of wire netting were fitted on the lower flanges and the concrete placed on these, being filled in from both sides towards the crown. The end of each I-beam rests on a vertical 60-lb. rail embedded in the abutment, and a diagonal rail is embedded in each wing wall. This arrangement enables lighter walls to be used, with an economy in concrete, and a saving of about 30% in cost as compared with a structure having concrete abutments and an open I-beam floor. All concrete work is made with Portland cement supplied by the Wabash Portland Cement Co., of Detroit, Mich., with works at Stroh, Ind.

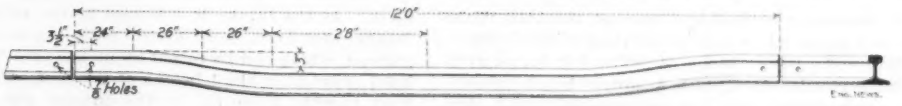


FIG. 3. DROP RAIL AT SWITCHES.

STATIONS AND BUILDINGS.

The Chicago terminal is a transfer station for connection with the Garfield Park line of the Metropolitan West Side Elevated Ry., as described in our issue of Aug. 14. The cars run between two platforms, on the outer sides of which is the terminal loop of the elevated railway, which is reached by an incline from the elevated station at 48th St., as described in our issue of July 31. At Elgin and at Batavia the line runs on its own right of way up the river bank to a terminal station in the center of the town. At Aurora the cars run for about half a mile along a street, but the tracks are adjacent to the right of way of the Chicago, Burlington & Quincy Ry. There are about 30 stopping places in all, most of these having simply open platforms at road crossings. Each of the six brick substation buildings has a waiting room and platform for passengers, and there are a few small frame stations. The main repair shops and car sheds are being built at Wheaton, and are of fireproof construction throughout.

CAR EQUIPMENT.

The road has about 30 cars, and others will be added as the traffic requires. Those now in use were built by the Niles Car & Mfg. Co., of Niles, O., and were all run to Chicago on their own wheels. One of these is shown in Fig. 8, which also shows the track and third rail. They are 47 ft. 3 ins. long over all, 8 ft. 8 ins. wide, and weigh 74,000 lbs. empty. They are of substantial construction, with steel underframes stiffened by truss rods, and steel-framed trucks. The wheels are 36 ins. diameter, and the axles 6½ ins. diameter, with journals 5 × 9 ins.; the axles, boxes, etc., conform to the M. C. B. standards. There is a motor of 125 HP. on each axle, and nearly all the cars are thus equipped, the line being operated mainly by trains of three to five cars; the electrical equipment is on the multiple-unit system, in which all the motors are controlled from the controller on the front car. There will, however, be some trail cars without motors. Contact shoes are fitted on both sides of each truck, and there are two trolley poles on the roof for use on the short piece of street line in Aurora. The cars have transverse seats, upholstered in rattan, and have seating accommodation for 56 passengers. They are equipped with telephones, Christensen air brakes, electric heaters and electric interior lights and headlights. At one end is a smoking room. The platforms are vestibuled and have side and end doors in the vestibule, the latter allowing for access between the cars when coupled up in trains. Hinged sections of the floor cover the steps when the doors are closed, and when the car reaches the 52d Ave. transfer station (which has a high platform). The dimensions of the cars correspond very closely with those of the cars on the Chicago elevated railways, and the trucks are so arranged as to enable the cars to

FIG. 4. CONCRETE-STEEL BRIDGE OVER SALT CREEK; AURORA, ELGIN & CHICAGO RY.

FIG. 6. CATTLE-PASS WITH DOUBLE OPENING.

readily pass the 90-ft. curves on these lines. This is in view of the possibility of eventually running the cars over the elevated railways into the city.

POWER PLANT.

The current for operating the entire line is generated at one power house, at Batavia, Ill.; this will also supply current for the line from Elgin to Aurora, and for the street cars in these cities. This will not only give greater economy than the present small power stations on these older lines, but the city traffic will tend to equalize the load on the power station and prevent the high peaks which occur when only interurban traffic is operated. The power house is 202 × 160 ft., of steel frame construction, with a simple but handsome exterior of limestone and common pale brick, and a roof of tar and gravel composition on plank sheathing. The concrete foundations and the masonry were built by the company, while the steel work was built and erected by the Variety Iron Works, of Cleveland, O.

There are three Corliss cross-compound condensing engines of 2,200 HP., built by the C. & G. Cooper Co., of Mount Vernon, O. These have cylinders 32 × 60 and 64 × 60 ins., with a piston speed of 750 ft. per minute at the normal speed of 75 revolutions The receiver is in the basement, and contains a heater coil. On the shaft of each engine, between the cranks, are mounted a revolving field General Electric generator of 1,500 KW. and a 20-ft. 80-ton flywheel. Space is provided for a fourth engine and generator. There are also two horizontal engines of 200 HP., built by the Phoenix Iron Works, of Meadville, Pa.; each of these drives an exciter of 160 KW. The lubrication is effected by the Siegrist pressure circulating system, the pumps of which are arranged in duplicate for three independent sets of circulating pipes for engine oil, high-pressure cylinder oil, and low-pressure cylinder oil. The oil room in the basement has two tanks for each of these oils, so that one can be filled while the other is in service; in this room also are two Cross filters for the waste oil, made by the Burt Mfg. Co., of Akron, O.

All piping is exposed and within view, instead of being concealed in tunnels or a basement. The main lines of pipe are carried horizontally along the wall of the engine room, the valves being made accessible by an iron L-shaped ladder which travels along the whole length of the wall. With this arrangement all the principal pipe connections, valves, etc., are in full view of the men in the engine room. This room is served by a 50-ton electric traveling crane built by Alfred Box & Co., of Philadelphia, Pa., and a railway track enters one end of the room so that material can be handled directly from the cars by the crane.

Steam is supplied by eight water-tube boilers of 500 HP., built by the Edge Moor Iron Co., of Wilmington, Del., and space is provided for two more boilers. The boilers carry a pressure of 180 lbs. They are fitted with superheater tubes, and have the traveling chain grate of the McKenzie Furnace Co., of Chicago, driven from eccentrics on a shaft placed beneath the floor. The plant also includes Green economizers and Worthington condensers and pumps, the main circulating and feed pumps being driven by induction motors. The power station is close to the Fox River, and the water supply for the boilers and condensers is taken from the river by a conduit which passes through the building, while the waste water is discharged into a culvert which leads back to the river. At the intake is a screen house, with two intake chambers, each fitted with three wire screens, which can be raised by means of a trolley hoist running on the I-beams of the roof. To prevent trouble from ice at the intake, an 18-in. cast-iron pipe is run to it from the condensing plant so that some of the warm water from the condensers can be discharged at the intake instead of into the culvert. The 240-ft. chimney, of brick and stone, is placed at the middle of the building, and the top of its 11-ft. flue is 225 ft. above the grates.

The coal-handling plant is of rather novel design, no continuous conveyor being used. The coal is dumped or shoveled from railway cars into a masonry storage bin parallel with the boiler room, and divided into 18 pockets, each of which has a capacity of 3,771 cu. ft., the total storage capacity being about 2,000 tons. The bottom of each pocket has two steel hoppers, the two rows of hoppers being separated by a stone wall pierced with archways. Under each row is a track of 21½ ins. gage, the rails being embedded in the concrete floor of the basement (below the boiler room floor), and arranged for outside-flange wheels, so that the concrete between the rails is made flush with the rail heads and the floor is easily kept clean. A transverse track runs to an Otis elevator, and has turntables at its intersection with the two tracks under the coal hoppers. On these tracks run steel cars of 1 ton capacity fitted with ball bearings. A car is loaded by a gate at one of the hoppers, and then run to the elevator, the floor of which carries a turntable with automatic weighing device. This raises the car to the level of a track running along the tops of hoppers of 5 tons capacity above the stokers, and it is run to the right or left along this track and dumped into any one of the hoppers, as required. From these hoppers, spouts lead to the automatic stokers or chain grates. Under the ashpits passes another track of 21½ ins. gage, on which are run similar cars, which are raised by the elevator and then run over a storage bin above the coal car tracks (above the coal bin), from which the ashes may be dumped into railway cars and hauled away for filling, etc. One man can handle a ton of coal from the storage pocket to the boiler hopper in eight or ten minutes, and two men can easily handle all the coal and ashes. This coal and ash-handling plant was designed by the engineers, and built by the Variety Iron Works, of Cleveland, O.

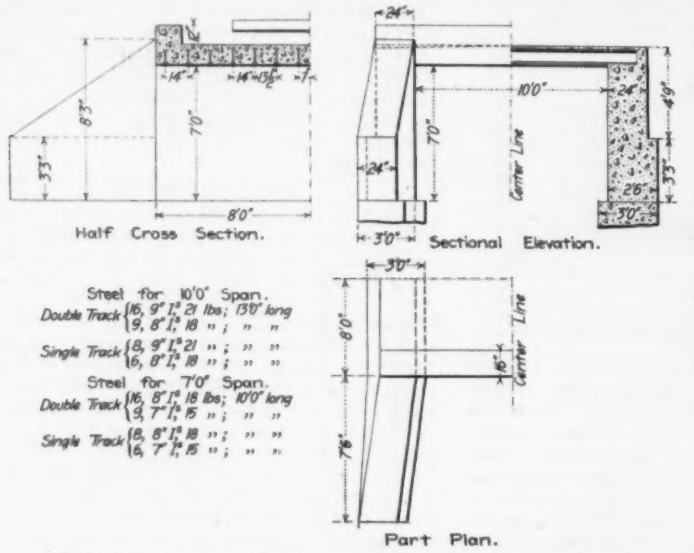

Half Cross Section.
Sectional Elevation.
Steel for 10'0" Span.
Double Track 16, 9" I., 21 lbs; 130' long
9, 8" I., 18 " ; " "
Single Track 8, 9" I., 21 " ; " "
6, 8" I., 18 " ; " "
Steel for 7'0" Span.
Double Track 16, 8" I., 18 lbs; 100' long
9, 7" I., 15 " ; " "
Single Track 8, 8" I., 18 " ; " "
6, 7" I., 15 " ; " "
Part Plan.

FIG. 5. STANDARD CATTLE-PASS; AURORA, ELGIN & CHICAGO RY.

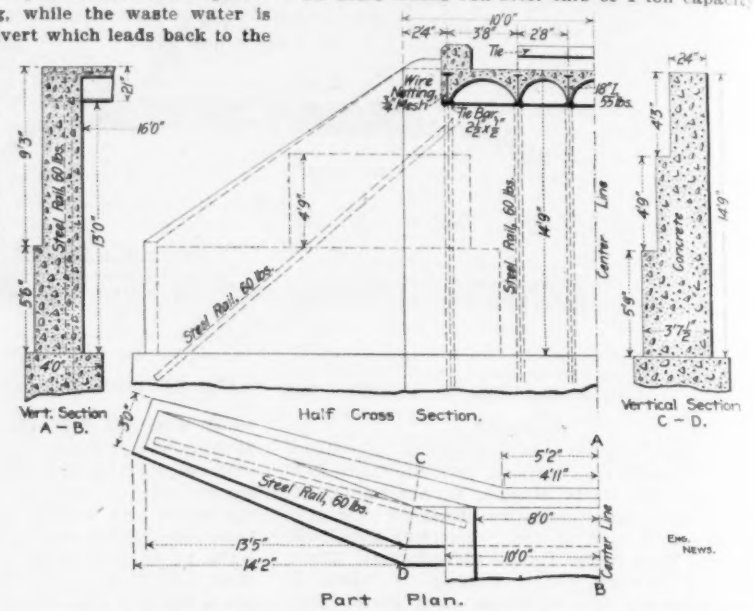


FIG. 7. CONCRETE-STEEL BRIDGE WITH CONCRETE JACK-ARCH FLOOR.

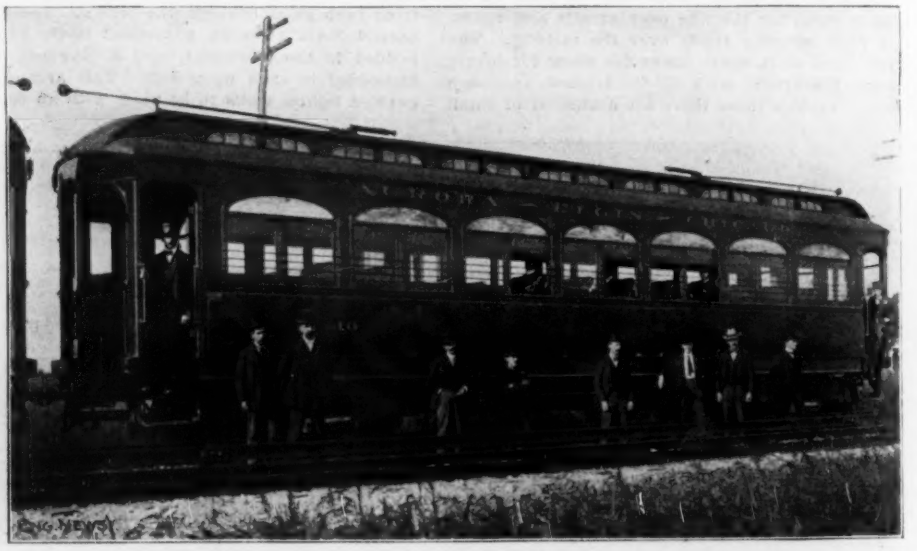


FIG. 8. CAR FOR HIGH-SPEED THIRD-RAIL ELECTRIC INTERURBAN SERVICE; AURORA, ELGIN & CHICAGO RY. Niles Car & Mfg. Co., Niles, O., Builders.

The transformers are on the engine room floor, and are cooled by a current of air passing up through them. Two fans deliver the air into a blast chamber, or bus-bar room, in the basement, which is a long room under the transformers and containing the connections for the outgoing high-tension wires. This room is entered by means of an air lock, formed by double doors having openings fitted with shutters.

The power plant generates an alternating current of 26,000 volts, which is sent out over the high-tension cables to the substations. Stationary transformers reduce this to a 420-volt alternating current; this enters the rotary transformers, which deliver a 600-volt direct-current to the third rail. The arrangement of the high-tension current is shown in Fig. 9, from which it will be seen that provision is made for alternative circuits in case of failure in emergency. Each circuit consists of three aluminum cables, arranged in a triangle, 20 ins. c. to c. These are transposed at intervals of a mile. The high-tension cables do not extend to the ends of the line, the end sections (indicated by dotted lines) having the third rail fed directly from the substations, so that the poles carry only the telephone wires. The poles carrying the high-tension cables are 40 ft. long and 80 ft. apart, and the telephone wires are carried on the same poles, below the cables. On the end sections of the line the telephone wires are carried by smaller poles 100 ft. apart. The telephone wires are transposed on every fourth pole.

There are six substations, the location of which is shown in Figs. 1 and 9. They are approximately 10 miles apart, feeding the third rail for five miles in each direction. All these are fireproof buildings

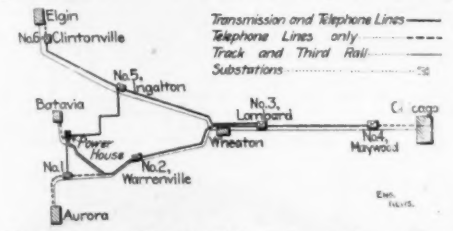


Fig. 9. Plan of Electric Distribution System; Aurora, Elgin & Chicago Ry.

of brick and stone, with Monier concrete-steel floors; and they have waiting rooms and platforms to serve also as passenger stations. Each substation has six stationary air-cooled transformers, two rotary transformers, and a fan with induction motor (supplied by the Buffalo Forge Co., of Buffalo, N. Y.) for supplying the air blast to the transformers.

ENGINEERS AND CONTRACTORS.

The railway is owned by the Aurora, Elgin & Chicago Ry. Co., 100 Washington St., Chicago. The officers of the company are as follows: President, L. J. Wolff, and Treasurer, M. J. Mandelbaum, both of Cleveland, O.; Secretary, Warren Bicknell. The Chief Engineer is Mr. Charles Jones; Construction Engineer, E. H. Arnold; Electrical Engineer, E. Gonzenbach. The headquarters of these officers and for the operation of the line are at Wheaton, Ill. The contractors for grading were the Pound Construction Co., of Chicago, for the line from Chicago to Aurora and Batavia; and the Bracey, Howard & Foster Co., of Chicago, for the Elgin line. The latter company also did all the tracklaying and ballasting. The power plant and electrical engineering work was designed by the Cleveland Construction Co., of Akron, O.; Will Christy, President; W. E. Davis, Vice-President and Electrical Engineer; and W. L. Morris, Mechanical Engineer. The General Electric Co., of Schenectady, N. Y., had the contract for all electrical equipment. The other principal contractors have already been mentioned.

SPECIFICATIONS FOR CONCRETE WORK; AURORA, ELGIN & CHICAGO RY.

The use of concrete for railway bridges, culverts, bridge piers and abutments, retaining walls, and other structures has been increasing very rapidly within recent years, and this is especially true of the electric interurban railways which are now becoming so numerous. On the third-rail interurban line of the Aurora, Elgin & Chicago Ry., concrete has been used very extensively, the structures ranging from small box culverts to 10-ft. flat-top I-beam and concrete culverts, and arches of 12, 15, 30 and 35-ft. span. Some of these arches are of concrete alone, while others have old 60-lb. rails (36 ins. apart) embedded in the arch, being curved to about the radius of the center line of the arch ring. Some further particulars of the concrete structures are given in our article upon this railway in the preceding pages. It may be noted that all these structures were built of Portland cement from Stroh, Ind., supplied by the Wabash Portland Cement Co., of Detroit, Mich.

As so much of this class of work is now under construction, and as the specifications were carefully drawn up, we give these specifications below, in the belief that they will be of interest to many of our readers. These specifications were drawn up by Mr. Charles Jones, Chief Engineer of the Aurora, Elgin & Chicago Ry., and Mr. E. H. Arnold, Constructing Engineer, both of Wheaton, Ill.

Some of the provisions of the specifications are worthy of special attention, and perhaps the most notable of these is in regard to the measurement of cement. There is considerable difference of opinion not only as to how the cement should be measured, but also as to the actual meaning of the terms of some specifications in this respect. At the annual convention of the American Railway Engineering and Maintenance of Way Association in March, the late Prof. J. B. Johnson started an animated discussion on this point, showing that in very many cases it is not stated whether cement is to be measured loose or in the original package, while a difference of nearly 50% may be made in measuring the same quantity by the two methods. Some of the speakers favored specifying the cement to be measured "loose," and others favored specifying "in the original package," while others specified a certain weight per cubic foot of cement. In the specifications quoted below it will be seen that the proportions are expressed as units of volume, a quarter-barrel sack of Portland cement as packed by the manufacturer being taken as a cubic foot.

In building walls with sloping tops, the practice of the Illinois Central Ry. was first followed. Under the specifications of that road (Eng. News, July 18, 1901), the work is built in horizontal sections, and the slope finished in short sections of 3 to 4 ft. in length and bonded into the horizontal sections before the concrete of the latter has become set. At each junction of adjacent sections of the slope there is a groove across the top of the wall. This plan, however, was not found to work satisfactorily on the Aurora, Elgin & Chicago Ry., and the method described below was adopted. This consisted of marking off the slope on the inside of the form and building the wall in steps, which did not come within 6 ins. of the slope. This being completed, the space between the steps and slope line was filled in with concrete and finished off with a mortar surface, thus giving an even and unbroken surface for the top of the wall.

As to the consistency of the concrete, it is required that the concrete should be wet enough for water to flush to the surface after thorough ramming, and a slight excess of water is considered preferable to a deficiency. The method adopted for facing the work is to have an iron plate fitted with angle irons which keep it 1½ ins. away from the surface of the mold. This space is filled with fine mortar, while the ordinary concrete is filled in behind, the plate being then drawn up and the whole mass tamped so that the facing will be thoroughly incorporated with the backing.

With this introduction we give the specifications below, practically in full, with certain modifications from the original form which have been introduced as the result of experience with the work done under these specifications:

SPECIFICATIONS FOR CONCRETE WORK.

1. Concrete masonry will be constructed in three grades:

2. Class A. Will be composed of 1 part Portland cement, 2 parts sand and 4 parts stone. This grade will be used in arch sheeting, bridge seats, parapet walls, and such other parts of structures as may be required by the engineer.

3. Class B. Will be composed of 1 part Portland cement, 3 parts sand and 6 parts stone. This grade will be used in abutments, bench walls for arches, retaining walls, or such other work as directed.

4. Class C. Will be composed of 1 part Portland cement, 4 parts sand and 8 parts stone. This grade may be used in foundations and other work as directed by the engineer. This class of concrete will permit the use of irregular shaped rubble stone of about 1 cu. ft. in size and less, laid in each course, and so arranged as to leave a space of not less than 8 ins. between adjacent stones, and no stone to be within 8 ins. of the face of the wall.

5. The proportions above expressed are units of volume, a quarter barrel sack of Portland cement as packed by the manufacturer being accepted as a cubic foot. The sand must be measured loosely.

6. The proper quantities of sand and stone for each batch must be measured in a manner satisfactory to the engineer, so that there can be no doubt that the required proportion of each kind is delivered. The use of barrels or boxes without heads and bottoms, into which the sand and stone may be cast, the containing vessel then being removed, will be deemed satisfactory, or preferably the use of square and uniform sized wheelbarrows built specially for this service. The use of the ordinary shallow wheelbarrow will not be permitted.

CEMENT.

7. The cement will be an American Portland and must be of a manufacture approved by the chief engineer, and the contractor will not be allowed to make concrete with any other brand. Contractors will be required to provide a suitable storehouse at the several structures in which the cement may be stored so as to be protected from the weather and from dampness from the ground. A sufficient quantity shall be kept in the vicinity of the work so as to allow ample time for tests without delay to construction. In addition to the usual tests the inspector will be required, from time to time, to make small pats of pure cement, and of cement mixed with sand, in order to satisfy himself that the cement going into the work is uniform in character and has not been injured by exposure. He shall reject all cement that is lumpy, or fails to set in proper time, and the contractor shall remove the same from the work.

SAND.

8. All sand must be clean, coarse and sharp; sand from bank or pit preferred. It must be free from loam or clay. If necessary to meet these requirements, it shall be screened and washed as directed by the engineer.

STONE.

9. The crushed stone used in the concrete must be made from hard, clean limestone, free from earthy or clayey matter, or rotten stone. It must be the entire product of the crusher passing through the screens up to and including stone of 1½ ins. size. The screenings, or all that passes through the ½-in. screen, must not exceed one-sixth of the whole, and be reasonably free from dust.

10. The water used must be fresh and clean.

MIXING.

11. A suitable platform must be prepared of convenient size and so constructed as to keep the ingredients entirely free from mixture with all foreign matter. Not more than 1 cu. yd. of concrete shall be made at once. In preparing a batch by hand, the measured quantity of sand must first be spread upon the platform, 2 or 3 ins. thick. Upon the sand the proper quantity of cement will be evenly spread. The sand and cement shall then be thoroughly mixed dry by turning and re-turning with a shovel at least three times, or oftener if required by the inspector. The proper amount of broken stone, having previously been wet, shall then be spread uniformly upon the mixed sand and cement; the whole shall then be turned over by shovels at least twice before loading into wheelbarrows for depositing in the molds. During the turning of the stone with the dry sand and cement, the mixture must be wet by a spray or sprinkler; water must not be dashed or thrown upon the mass in quantities to wash.

12. The contractor must see that the resultant mixture is uniform in character, and that all the stone is covered on all surfaces with the mortar. The contractor must see that the proper amount of water is used; that the concrete is neither too wet, nor too dry; a slight excess of water, however, being preferred to a deficiency. It should be wet to that degree that after thorough ramming the mortar will flush to the surface. Concrete mixed by machinery must correspond in all respects to that above described; special care being taken that the ingredients are so delivered to the machine that the resultant mixture is uniform in character, each shovel full having the prescribed proportion of the different materials, and of the desired consistency.

PLACING THE CONCRETE.

13. Immediately after the mixing, the materials must be deposited in the molds in layers not exceeding 4 ins. in thickness; these layers must be carried up level and no wavy or irregular lines will be permitted to show on the face of the work. Concrete which has begun to set before being placed and rammed will not be allowed to remain in the work.

14. After being placed, each layer must at once be thoroughly rammed and consolidated so that no void spaces are left. The contractor must insist upon the thorough ramming and compacting of all concrete, as the value of the work largely depends upon the completeness with which this highly important part of the work is done. He must see that a sufficient number of men are provided with suitable rammers so that each batch is spread and well compacted before another batch is delivered within the molds, and when this labor is specially severe, the contractor should require the changing of men so employed in order that this part of the work may be thoroughly performed.

15. Layers should not be tapered off, but be built with square ends and when from any cause it becomes impracticable to complete a layer, a plank of convenient width should be secured to the mold against which the concrete shall be rammed, thus making a vertical joint. Should it be necessary to start a second layer at once, it should stop short of the first plank at least 12 ins., when a second plank must be secured in the same manner as the first, and the concrete rammed against it, the layers being carried up full thickness to the board, and left rough. No loose stones or porous places should be left on the surface of any layer, but such places must be filled with mortar, and the ramming repeated until wet mortar flushes to the surface. The top surfaces and also the sides of all stepped footing courses in foundations must show smooth

mortar faces, and if necessary to secure this, sufficient mortar of 1 part cement to 3 parts sand shall be made and applied.

ARCH CULVERTS.

16. In the construction of long arch culverts the work may be divided into sections of 20 to 25 ft. in length by temporary partitions extending from the top of the footing course through the bench wall and arch sheeting; against this temporary partition the concrete must be rammed. After the completion of a section and the setting of the concrete, the temporary partition will be removed, and the next section started against the concrete, but no mortar must be used to flush the joint, or bind it to the section first built, in order that any contraction may open the joint, or settlement of the foundation may cause sliding without breaking the concrete.

17. In similar manner in large arches, sections shall be set off by partitions parallel with the axis of the arch (the size of these sections to be determined by the engineer), the temporary partitions to be on truly radial lines. Against these partitions the concrete shall be well rammed. After the concrete is well set the partition shall be removed, and another section started, no mortar being used at the joints. The object is to construct the arch of clearly defined sections, capable, should occasion require it, of some slight sliding adjustment without fracturing the mass.

18. The backs of all arches must be covered with a layer of motar not less than ½-in. in thickness, composed of 1 part cement to 2 parts sand.

FORMS.

19. In constructing all forms of concrete masonry, the casings or molds shall be substantially built of planks sufficiently heavy (in general 2 ins. thick) to hold the concrete. These planks must be surfaced on two edges, and one side so as to be of uniform thickness. They must be neatly fitted together so that the mortar face shall be as smooth as possible, without showing the ends or edges of the planks. In order that the faces of the masonry may be true, the sides of the forms must be firmly braced and secured by rods or wire extending through the concrete. On the removal of the forms, all such wire and tie rods must be cut off at least 1 in. beneath the surface, and the holes neatly filled with mortar. A competent carpenter must be employed in the erection of the forms, and all work must be done in a workmanlike manner. The molds for bridge seats and projecting copings, when such are ordered, shall be constructed in a first-class manner so as to make smoothly finished work. When edges of wing walls, bridge seats, or tops of parapets, or other parts of the work are required to be beveled or rounded, molds of proper shape shall be used, and all forms so constructed that the resultant work shall be finished true and in a workmanlike manner.

20. Where sloping walls are used, as in the wings of abutments, the casings must be built to full height; then upon the inside a line will be drawn at the top surface of slope. The wall will next be built up in steps of convenient size from 18 ins. to 36 ins. on the horizontal, with risers of 12 to 24 ins., care being taken that no part of the step is nearer than 6 ins. to the slope line. Immediately after the wall has been built up in steps, concrete will be filled in to near the top line so that the finishing surface of mortar will bring the sloping face to the height indicated by the line. The mortar will then be floated to a true surface and worked off with a sidewalk finish. This sloping surface above the steps must be built continuously in one operation.

FACING.

21. For all concrete work in abutments, arches, piers, retaining walls, or in other construction required by the engineer, a facing mortar of 1 part cement and 2 parts sand shall be used on all surfaces exposed to the weather, or which may be exposed, also the intradoes of all arches and the upper 12 ins. of wing walls and parapets. This mortar facing shall be 1½ ins. thick, and secured in the following manner: pieces of sheet iron of convenient width and length, with suitable handles attached, and having angles with a projection of 1½ ins. riveted at intervals of 24 to 30 ins., shall be furnished by the contractor. The angles being placed against the molds, the space between the plate and the mold shall be filled with the mortar described above, which must be mixed in small batches as it may be needed; it must be of such a consistency as to readily fill the space, without being so thin as to allow the stone in the concrete to be forced through it. When the space is filled with the mortar and tamped with a suitable tool to insure complete filling of the entire 1½-in. space, and the ordinary concrete is filled against the plate, this last must be withdrawn, and the whole tamped as described, so that the face and the back are built up together. The contractor must see that this mortar face does not follow nor precede the concrete mixture, but must be built up with it. Bridge seats and the top surface of parapet walls must be finished as described in Paragraph 20; that is, floated to a true surface and worked off with a sidewalk finish.

22. For the backs of abutments and retaining walls, it will be sufficient in forming their back surfaces that the concrete be forcibly cast against the forms, thus working the finer portions of the mixture against the casing, and then thoroughly tamping it. The top 12 ins. of wing walls, abutments and parapets, however, to be finished as described in paragraph 21.

23. No concrete surface with pores or open spaces shall be covered with earth; such open work must first be pointed.

GENERAL.

24. When it becomes necessary or expedient in the judgment of the engineer to use I-beams, or steel rails, or iron in any form in the concrete, an allowance equal to the actual cost of handling such iron shall be made to the contractor and the volume of iron shall be estimated as concrete.

25. After the work is well set the forms shall be removed by the contractor. Concrete shall have at least 48 hours to set after the completion of the work, or longer in cold weather.

26. No concrete shall be laid in freezing weather except upon the order of the engineer, with special instructions as to the conduct of the work, and its protection from the frost. In hot, dry weather the contractor must see that the crushed stone is frequently wet, and that the concrete is wet from time to time in order to prevent drying before hardening. In dry weather all exposed surfaces of new work must be kept moist at least three days.

27. The contractor will be required to furnish all plank, timber, braces and tie rods, or other material required in construction of forms for concrete masonry, for which no allowance will be made, nor for any scaffolding, nor centering on arches (except when necessary to use trusses) nor other timber used in masonry construction, except such as is necessarily left in the work, the cost of all such material being included in the contract price per cubic yard of completed work.

28. All walls when finished must present a smooth uniform surface of cement mortar, and all disfigurements must be effaced, and if there are any open, porous places, they must be neatly filled with mortar of one cement and two sand, well rubbed in, which finishing must be done immediately upon the removal of the forms. Compensation for all labor and material required in such finishing, including the mortar facing when required, with the finishing of bridge seats and other parts, is included in the price per cubic yard for concrete work.

COLLAPSE OF A 200-FT. HIGHWAY BRIDGE OVER THE COLORADO RIVER AT GONZALES, TEX.

We illustrate in the accompanying cuts the wreck of a highway bridge crossing the Colorado River at Gonzales, Tex., which collapsed on Aug. 1, 1902, owing to the failure of one of the double-cylinder piers on which it was carried. The bridge was a through pin-connected truss span of 200 ft.; the width between trusses being 20 ft., and the trusses being divided into ten 20-ft. panels. The total weight of the span was about 100 tons, and it rested upon two steel tubular piers each made up of a pair of steel tubes 54 ins. in diameter. The tubes of the pier at the town end, which were the ones that failed, were about 50 ft. long, and they were sunk to a cemented gravel stratum some feet below the bed of the river. The tubes failed by tipping over toward the stream, they being ridden over the bank and crushed down by the span, the pier seats of which sunk into the ground some 10 ft. The opposite end of the span remained in place on the far pier.

Fig. 1 is a view of the wrecked bridge, showing the wrecked pier at the far end, and Fig. 2 is a near view of the end which fell. The four pyramidal structures shown underneath the bridge in Fig. 1 are old I-beam and concrete piers which supported the 140-ft. King arch, built some 30 years ago and which were left standing when the old arch was replaced by the new steel span built last June. These old piers, as is clearly shown by Fig. 2, did considerable damage to the falling bridge by crushing up through the metal work; three panels of the steelwork were pretty badly mutilated by them. They, however, served a good purpose by catching and supporting the span and thus preventing it from turning over or sinking further into the mud. On the whole this bridge seems to have been of fairly good design, except that the hip verticals are not what good modern practice demands, and that no bracing seems to have been used between the pier cylinders. The information available does not show, however, whether or not the latter defect contributed in any way to the failure.

Immediately after the wreck the local authorities awarded a contract for repairing the bridge to E. P. Alsbury & Son, of Houston, Tex. The contract price for the work was $5,700 and included the repairing and replacing of ruptured members, the construction of a new pier and the addition of a 54-ft. span between the new pier and the river bank. The fallen tubes weighed about 60 tons and had to be taken out from under about 30 ft. of soil and caving banks. The falseworks used was of framed bents and two 40-ft. gallows frames were used in taking out the span. The wrecked span stood on an 18% grade and the falseworks and gallows frames were built to suit this grade. Within twelve days after work was commenced the entire wreck, including the pier and falsework, were entirely removed and on the shore ready for repairs and replacing. It was expected on Sept. 2 that the bridge would be re-erected and ready for traffic in about three weeks.

During the work of reconstruction the temporary structure, shown by Fig. 3, was employed to accommodate the traffic. This structure is described as follows, in a letter to us from the contractors:

> The good citizens of Gonzales attempted to give the people a quick and temporary crossing by making two 40 × 15-ft. barges and connecting them with aprons. The point selected for this temporary structure is the swiftest point on the river, the current running fully 20 miles an hour, and for a width of 50 ft. this rapid current is 10 to 12 ft. deep. When the boats were put into the river they turned over and sank. No nose or rake being built on the upstream side, the force of the water pressed the upper side under and coming over filled and sank the boats. The boats were not properly constructed, only a 10-in. gunwale being used, and they were roughly jointed and not calked. We suggested a temporary log trestle, but they desired to use these flats which they had built, and the only way we could see to use them, was to pick them up and hold them in place; first putting a rake on the upstream side. The boats are carried and held upstream by four stationary gallows frames built of 6 × 8-in. timbers and resting on the bottom of the river. There is a 15-ft. space between the barges and in case of a small rise this apron can be removed and drift guided through. The barges are allowed to settle two-thirds of their depth in the water so as to cause the displacement to carry part of the load, the rigging carrying about one-third of the traffic. The work was put in place and traffic opened within 14 hours after our foreman and a few of the boys started, and has given a crossing on some days to 1,000 bales of cotton coming in from the country. About 6,000 ft. of line is in use and should the river rise the barges can be pulled up accordingly. The people are well pleased with the result and the town is saved a loss of $1,000 country trade a day, which would have drifted to the adjoining towns.

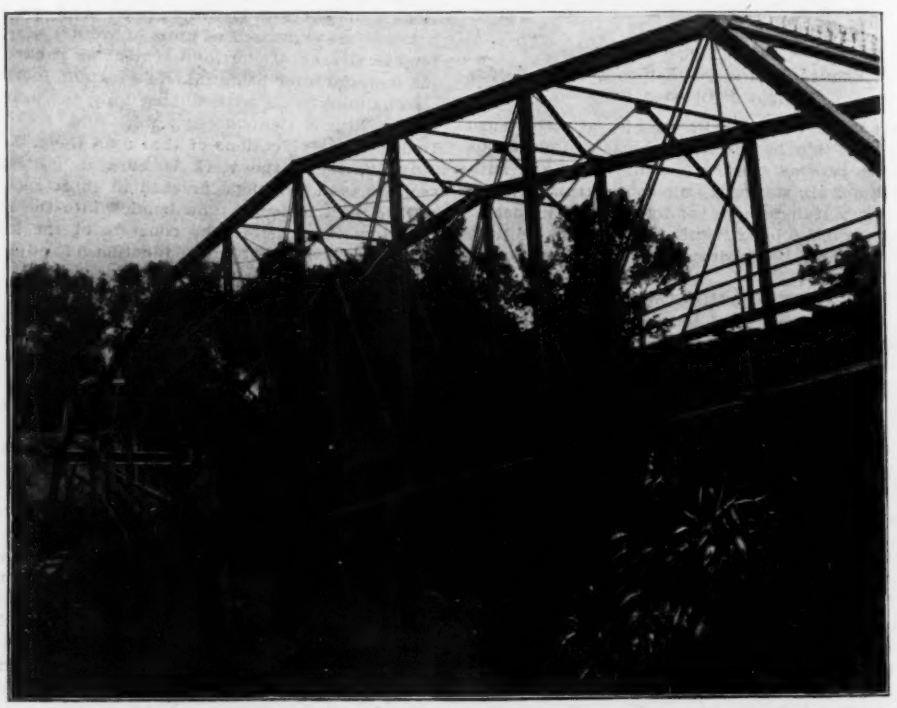


FIG. 1. GENERAL VIEW OF WRECKED BRIDGE OVER COLORADO RIVER AT GONZALES, TEX.

We are also indebted to the contractors for the information and the photographs from which this description has been prepared.

THE DUTY OF THE ENGINEER TOWARD CONTRACTORS.

The recent editorial discussion concerning specifications for engineering work has brought to our attention a paper recently read before the Engineers' Club of Philadelphia, in which the same or a kindred subject is treated in an admirable way. The author of the paper, Mr. L. Y. Schermerhorn, M. Am. Soc. C. E., has had many years of experience both as an engineer and as a contractor on important works. It will be remembered that in our editorial discussion hitherto, we have emphasized three important principles: (1) That the engineer should carry the responsibilities that are rightly his and not attempt to unload them onto the contractor. (2) That the task of the contractor should be made plain to him in the specifications. (3) That the element of risk should be eliminated from the contract, so far as possible. We reprint below, somewhat condensed, Mr. Schermerhorn's paper, and the reader will note how well it agrees with the views set forth in our recent editorials:

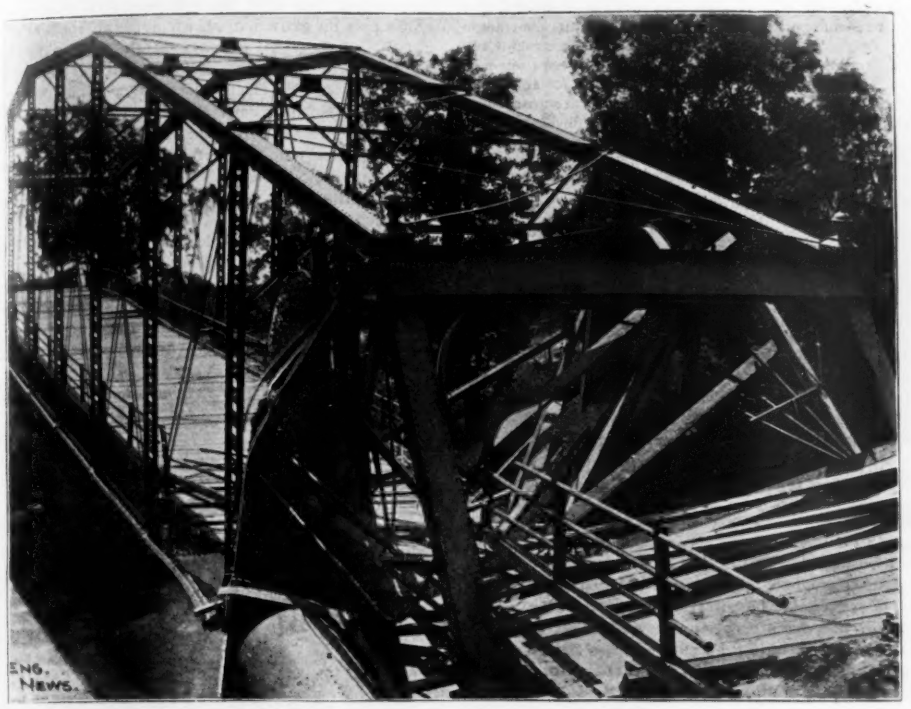


FIG. 2. VIEW SHOWING WRECK OF STEEL WORK CAUSED BY OLD PIERS ON WHICH THE SPAN FELL.

The engineer in responsible charge is generally either the author of the plans and specifications upon which the work is to be carried into effect, or he is the employed agent of such author. In either case his relations to the contractor are the same. He is assumed to be an expert in the work which he designs or directs, and the assumption warrants the inference that his knowledge of the work in all its details is as great as, if not greater, than that of the contractor. This assumption is justified by the usual declarations of the specifications, making the engineer the only recognized interpreter of the meaning of the plans and specifications for the work covered by the same.

Through the preliminary study given to the development of the plans and specifications the qualified engineer should be able to acquire a fuller knowledge of the details of the work than can generally be obtained by the contractor through means and time usually at the latter's disposal, between the issue of the plans and specifications and the tender of the contractor's proposal for the work. This establishes the fact that, except in simple and routine constructive work, the designing engineer has a better opportunity than the contractor to thoroughly familiarize himself with all the difficulties and uncertainties of the work. Therefore in this respect the designing engineer enjoys an advantage over the contractor which it is his duty to recognize, through the plans and specifications, by fairly placing before the contractor full information upon points which otherwise would escape the contractor's knowledge. His duty is something more than to vaguely suggest possible difficulties and requirements, and then create for himself a refuge, by ignoring all responsibility for lack of reliable data, by providing that the information upon essential points in the specifications is not guaranteed, and that the contractor through his personal knowledge and examination will be assumed as having full and correct information upon all matters involved in the work, even though the engineer may have suppressed a part of his information. It goes without saying that the contractor has, in the end, to assume such responsibilities; but it should be based as far as possible upon a full knowledge and frank avowal of all that the engineer knows of the work.

This duty of the engineer is a delicate one, and the personal equation of the individual will largely determine his action in the matter. Should his personal views be interfered with by those of his employer, then the engineer must determine for himself how far the ethics of his profession and his duties to himself and his fellow-man will rightly permit his judgment to be overruled by his superiors. To intentionally suppress important information which would be difficult or impossible for the contractor to obtain is at once a crime against the public and an error which is more than likely to assert itself unfavorably in the work with which it is connected. Dishonesty in the administration of work will surely result in dishonest execution, and this in turn may lead to disaster, involving both property and human life.

Open, unqualified competition, without reservation as to awards thereunder, is an invitation and an encouragement to the incapable, unwise, and dishonest contractor to enter into competition with the contractor who believes that capacity, experience, and honesty are essential elements both to his success and to the success of the work that is to be carried into execution. When incapacity, inexperience, and dishonesty are joined with political pull and favoritism, the premium placed upon the dishonest execution of work is such as to forbid competition on the part of contractors who do not adopt such methods.

The duty of the engineer under such adverse conditions is plain, for he must either be in a position to demand and secure the proper execution of the work entrusted to his charge, or he must retire himself from a responsibility which is almost sure to result in the dishonest execution of his plans and designs. The engineer owes at once a duty to his employers and the public, through which, by all legitimate means, the incapable and dishonest contractor is excluded from the possibility of competing for work to be done under the engineer's direction; and if it is impracticable to accomplish such an end by not allowing this class of contractors to bid upon work, the power and authority should be inherent in the specifications to permit the exercise of a discrimination which can be used to prohibit his securing the work.

The undesirability of unqualified competition is well recognized through the manner in which individuals and many large corporations invite proposals for required work or materials; viz., by placing their proposals only in the hands of such parties as are known to be capable, experienced and honest. In the main, our cities and the general government are the only parties who do not adopt ordinary business methods in selecting their contractors, and where the only criterion is the lowest prices offered for the work to be done or the material to be furnished.

With the United States government this method of unrestricted competition is carried to the extreme, upon the theory that the bidder's or contractor's bond establishes the responsibility of the bidder or contractor; and more attention is given to very exact compliance with instructions as to the seals and notarial attestations upon the bonds than is given to the ascertainment of the fact whether or not the bonds have any real financial value. As a result of this method the government has constantly upon its public works failing and defaulting bidders and contractors, against whom legal action is seldom taken toward the enforcement of the penalties provided in the contract. While there may be a theoretic value in the moral effect of bonds and penalties named, such effect is lost upon the irresponsible and dishonest contractor, who through a long experience has gained a valuable knowledge of shrewd methods and tricks by which he can escape their enforcement, and upon which he fully counts when he enters into contract.

FIG. 3. TEMPORARY BRIDGE USED FOR TRAFFIC DURING RECONSTRUCTION OF WRECKED SPAN.

The engineer who is brought into administrative contact with the irresponsible and dishonest contractor will find himself quickly engaged in a conflict, whereby the efforts of the engineer to enforce the proper performance of the work will be met by every effort on the part of such a contractor to cheapen the work, or else to prepare the way for a successful escape from the penalties of his bond, if the work is not carried to satisfactory completion. The engineer who has gone through such experiences emerges

from the conflict always a disappointed, but generally a wiser, man.

From an experience of many years the speaker has been brought to feel that many engineers are inclined to hold a responsible and conscientious contractor to a more rigid enforcement, even of non-essentials, than an incapable and dishonest contractor to matters essential to the proper performance of the work. The reason for this is that it is easier to secure exact compliance from the former than even approximate compliance from the latter; but the question arises whether the engineer has a moral or professional right to attempt to move in such matters along the line of least resistance.

Considering the engineer as the direct agent of the parties who are to pay for the work done, it may not seem unnatural for the engineer to yield to the temptation of seeking the accomplishment of his work at the least possible cost to his employer, regardless of what he knows to be the real intrinsic value of the work. Adopting this view, some engineers encourage unqualified competition to its extreme, and attempt to reduce each letting of work to the methods and principles which surround the bargain counter.

Every work is worth its absolute cost as carried into proper execution under wise, economic, and efficient administration, plus a reasonable profit to the contractor. The engineer who seeks to accomplish his work at less than what he knows to be its true value violates the fundamental principles of sound business, and thereby lends himself to the perpetration of a fraud upon the public, and an injustice to his employer and his contractor.

The position which the engineer holds as to his employer and his contractor is without its parallel in the other professions, and his duties which arise thereunder to these parties are at once responsible and delicate. The engineer is quite generally made the only authoritative interpreter of the true intent and meaning of the plans and specifications; and the specifications more or less definitely provide that he shall determine every question, difference, or doubt in relation to and arising from the work undertaken, and shall decide every question which may arise relative to the execution of the contract on the part of the contractor; that his estimates shall be held as final; and that his specific conclusions and decisions shall be beyond appeal.

These broad and conclusive powers would suggest that the engineer is an arbitrator between his principal and the contractor, and clothed with the fullest power of decision and action; and yet the analogy is not complete. An arbitrator should be a disinterested party, and such the engineer is not. An arbitrator should not be under the pay or influence of either party; the engineer is manifestly under both from his principal. An arbitrator should have no interest in the questions he is to decide; the engineer is called upon to support his interpretations of his own plans and words, and to justify his estimates and conclusions generally. The position and its duties are anomalous, and a legal authority, commenting on the situation, said: "Under these conditions the contractor's rights depend upon his good luck in having his work under the supervision of an honest and conscientious engineer; and that the employer's obligations to pay or to perform depend upon his approval and the behavior of his engineer;" and that under such conditions "the courts undertake to guarantee the contractor that the employer or his engineer shall not capriciously nor unreasonably exercise his power to defeat the contract, or deny the contractor his just and reasonable compensation." No engineer has a right to force a reasonable contractor to carry into the courts the determination of questions that arise between them; for most contractors know that after resort to such an expedient their subsequent lot would not be a happy one; and that their position thereafter would be sadly prejudiced.

The apparent arbitrary power given to the engineer in the usual specifications and engineering contract, and which are probably generally conceded by the contractor, have their limitations in practice. Numerous decisions of the courts stamp with disapproval contract stipulations which tend to bind parties, before the occurrence of an event, to the arbitrary reference of matters arising from such events to an arbitrator without judicial functions. Neither have the courts regarded with favor the attempts of parties to oust their jurisdiction through unqualified agreements for arbitration. It should not be forgotten that all agreements for arbitration are revocable by either party at any time before the decision has been rendered by the arbitrator. This further indicates the attitude of the law toward arbitration. A very recent case decided by Judge Lawrence, of the New York Supreme Court, well illustrates this subject. Under a contract it was provided that, to prevent all disputes and litigations, it was agreed between the parties to the contract that the engineer should determine all questions of difference, and was to fix the amount and quality of the work to be done; and that the findings, estimates, and decisions of the engineer were to be final and conclusive. The court held that this provision in the contract was clearly to make the engineer the absolute and final arbiter as to all questions arising between the parties; that the provision in question, if made operative, would oust the courts of jurisdiction; and therefore it was decided as being void on the ground of being adverse to public policy. This decision is in harmony with well-established judicial maxims and conclusions, and is supported by a long line of decisions.

Through the very powers which are, of necessity, given to the engineer, he owes a duty to the contractor and to his employers to treat all situations and conditions which may arise with judicial fairness; and while entitled to insist upon the full and proper carrying into effect of the work undertaken, he should not forget that his contractor holds rights which honesty and justice demand shall receive fair recognition. To fully meet the requirements of such a situation and its duties bespeaks for the engineer the admirable traits which we believe are an accompaniment to the profession under its best development.

Contract such a view of the duties of an engineer to the contractor or his employers with the following as set forth in a text-book intended for the use of the profession.

> The engineer is in the interests of the proprietor, and receives his compensation from him. . . . He is not required nor expected to watch the contractor's business, nor to promote his interests, and any attempt to do so might render his position untenable, change the relations of the parties, and render the stipulation of his choice invalid. . . . The engineer owes no duties to the contractor except what he can demand by the terms of his contracts; he is under no obligations to protect his interests or assist him in his affairs.

I should be sorry indeed to believe that such a doctrine could be held by the engineer who dignifies his profession and its duties, and who believes that these duties have their foundation in honesty, intelligence and justice.

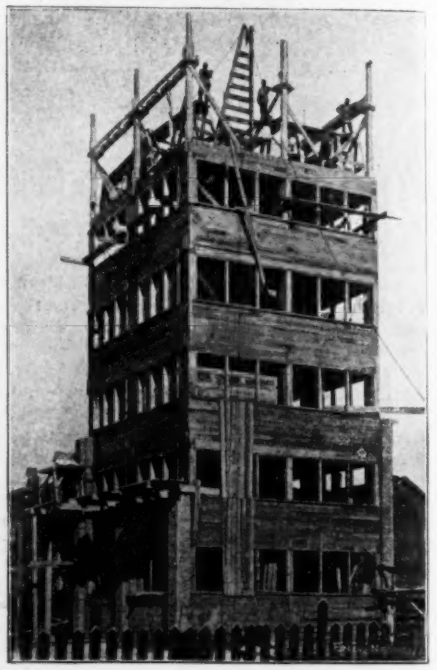
THE NEW YORK MEETING OF THE NEW ENGLAND COTTON MANUFACTURERS' ASSOCIATION.

The 73d semi-annual meeting of the New England Cotton Manufacturers' Association was held from Sept. 30 to Oct. 2, 1902, at the house of the American Society of Mechanical Engineers in New York city. The first session on the evening of Sept. 30 was devoted to addresses by Mr. Charles H. Fish, President of the Association; Mr. James M. Dodge, Vice-President Am. Soc. M. E., and Mr. J. Temple Gwathmey, President of the New York Cotton Exchange. Following the addresses refreshments were served. At the four sessions of the two days following, 18 papers pertaining to the subject of cotton manufacture and distribution were read. Of these several contained matter of interest to our readers. President Fish, in his address, said: "Every cotton manufacturer, no matter whether his knowledge has come to him through theoretical channels or through the hard knocks of personal experience, or by both, is, at least in a way, an engineer, although he may not have assumed the title of the honorable profession." Mr. Arnold B. Sanford in his paper on "Cotton Mill Expansion" emphasized again the relation between manufacturing and engineering when he said: "The successful mill superintendent in the near future will be the product of our textile schools." Some of the data which Mr. Sanford gave later shows the wonderful growth of the cotton industry in the Southern States during the last 12 years; at present the New England States have only twice as many spindles in operation as there are in the South. Speaking of the increase in shipments of American goods to foreign markets, Mr. Sanford stated that as a result of a recent visit of English manufacturers, 500 Northrop looms, made by the Draper Co., of Hopedale, Mass., have been shipped to England. In a paper entitled "Our Foreign Commerce in Cotton Goods," Mr. O. P. Austin, Chief of Bureau of Statistics, Washington, D. C., gave an excellent summary of facts and figures, and brought out one fact anent the "Yellow Peril" that is of interest. He stated that in Japan, where the number of cotton spindles are about three-fold what they were ten years ago, the rate of wages of workmen has in the same time doubled, while the importation of cotton has steadily and rapidly increased; and he adds regarding the seeming danger to our markets from a combination of American machinery and cheap Oriental labor to operate it: "We must not forget that increased earnings bring increased wants among the Orientals as elsewhere." Two more papers were read on cotton distribution, one, "The Export of Cotton Goods," by William P. Wilson, Sc. D., Director Philadelphia Commercial Museum, and the other paper was "The World's Supply and Consumption of Cotton," by Mr. S. N. D. North, Chief Statistician, Division of Manufacturers, U. S. Census.

Mr. Wilson said that as a trade mark in China "may have as much to do with the sale of a particular line of goods as the excellence of the [illegible] themselves," he had secured the services, for [illegible] Museum, of a Chinese artist and a Chinese [illegible] chant to select and paint in proper colors the [illegible] cal emblems suitable as trade marks for [illegible] branch of commerce. Mr. North brought out [illegible] interesting fact that the whole cotton crop of [illegible] globe can be grown upon an acreage represent[illegible] but 2% of the total acreage of the cotton prod[illegible] ing states of America. Another interesting st[illegible] ment was to the effect that every postmaster [illegible] the South is the agent through whom reports [illegible] cotton output are obtained from practically ev[illegible] cotton ginner who neglected to respond to the [illegible] ficial census circular.

Mr. William F. Parish, Jr., in a paper on [illegible] "Lubrication of Textile Mills," says that tab[illegible] giving coefficients of friction with various [illegible] guents are very misleading, for the tests upo[illegible] which such tables are based have been made with laboratory conditions of uniform temperature, freedom from dust, short time observations that do not show gumming up or other deterioration of the lubricant from exposure, and ill effects of dust and temperature variations. The paper, though short, is full of good advice on the selection of oils.

Mr. George C. Tewksbury gave the history and development of the Jones stoker (see Engineering



The Loring Wood Skeleton, Continuous System, of Mill Construction.

News, Aug. 9, 1894), in a paper entitled "The Under-feed Stoker," wherein it appears that E. W. Jones, the inventor, first made his mechanical stoker for a wood-burning furnace in the State of Oregon, the green wood being forced by a ram underneath the mass of burning wood. Such great success followed this method of firing that it has since been applied to coal with excellent results by the Under-feed Stoker Co., of Chicago. Mr. Tewksbury's experience leads him to believe "that an hourly fuel consumption of about 1,000 lbs. of coal is as great as should be attempted with one under-feed stoker," and "when greater fuel consumption is desired in any one furnace, two or more stokers should be used." He further believes "that an under-feed stoker, properly installed and properly operated, can be operated with much less expense for repairs than any other stoker because of the extreme simplicity of the same."

Mr. Sanford E. Loring, Architect, Syracuse, N. Y., read a paper, "Mill Construction on the Continuous Skeleton System," and illustrated the same with many blueprints and photographs. The skeleton system successfully used by Mr. Loring in a number of mill buildings is one in which timber is used to replace steel in the well-known

steel skeleton construction for brick or masonry buildings. The posts as made by Mr. Loring are built up of 3-in. yellow pine plank spiked or bolted together, and where the floor beams intersect the posts, there is provided a bearing casting of special design; horizontal and vertical slots are provided in the casting to permit two or more of the planks of the built-up posts and built-up floor beams to extend through so as to make the system of framing continuous. Brick is used only as a veneer 4 to 8 ins. thick, and for flues.

Fig. 1 shows a building of the type described, in process of erection. The meeting adjourned after electing 16 new active members and 8 associate members. There was an attendance of about 60 members and guests each day of the convention.

BREAK OF THE WATER-WORKS RESERVOIR EMBANKMENT AT CAMDEN, N. J.

The reservoir of the water-works of Camden, N. J., overflowed at 4 a. m., Oct. 2, resulting in one small washout of the outer slope and a cut through the entire embankment at the lowest point in its top.

The reservoir is a part of the original water-works built by a private company in 1853. The pumping station was located half a mile north of the reservoir, on the Delaware River, and connected with the reservoir by a 12-in. force main. In 1871, the city of Camden bought the plant and laid a 30-in. force main to the reservoir, with an inlet at the top of the reservoir. This 30-in. main was connected by a 30-in. by-pass to the old 12-in. main at the reservoir. The old main has four 12-in. connections to corresponding inlets in the bottom of the reservoir.

The reservoir (see sketch plan) is 180 × 244 ft. at the upper water line and 20 ft. deep, the sides sloping inward at an angle of 45°. It had a capacity of about 7,500,000 gallons. The material forming the embankment is a sandy loam, with an average cross-section 10 ft. in width at the top, 70 ft. at the bottom and 20 ft. in height. The inner slopes and the bottom of the reservoir are paved with 4 ins. of brick on 18 ins. of clay puddle.

Since the introduction of a new supply in 1898, the reservoir has been used only in case of accident. The pumps at the Morris Station driven well plant have been lately repaired, and the excess pumpage at night directed to this reservoir, and the reservoir supply used in the daytime to assist one pump at Morris Station to maintain a supply at lower pressure than usual. Both pumps were run on Oct. 1, and the reservoir remained nearly full. At 5 p. m., the chief pumping engineer directed the night watchman at the reservoir to close the 30-in. by-pass gate (the other 30-in. gate was kept closed) and states that he saw the watchman close it. From testimony it appears that the water was 2 ft. below the top of the brick coping of the lining at 5 p. m., and the watchman states that at 10 p. m. the water level was about the same. From these accounts it would appear that the brick lining extended to the top of the inner slope, and that the reservoir was sometimes filled to within 2 ft. of the crest of the embankment, a condition that it is hard to believe would be risked.

The by-pass valve already mentioned has a permanent hand well, and is easily accessible from the street, being inside a fence near a gate, and not covered or locked. Either the valve was not fully closed by the watchman or some unknown person partly opened the same for mischief.

The water overflowed the brick coping at two low places in the coping level. The small overflow cut out about 50 cu. yds. of earth and sod on the outer slope of the embankment. The other overflow probably began in the same way, running in a constantly increasing stream across the footwalk and down the outer slope, cutting the foot of the slope and working inward, increasing momentarily the vertical drop until the weakened bank gave way. The reservoir, being on the top of a small hill, with numerous streets across the same, the water spread at once on leaving the reservoir, the bulk of the water following the streets to low ground at the Pennsylvania Railroad repair shops. Considerable damage was done to fences, sidewalks and lawns. About a dozen cellars were flooded and holes broken into the cellar foundations of two houses. The floors of the railway shops and yard were covered with sand and water, requiring partial suspension of work that day.

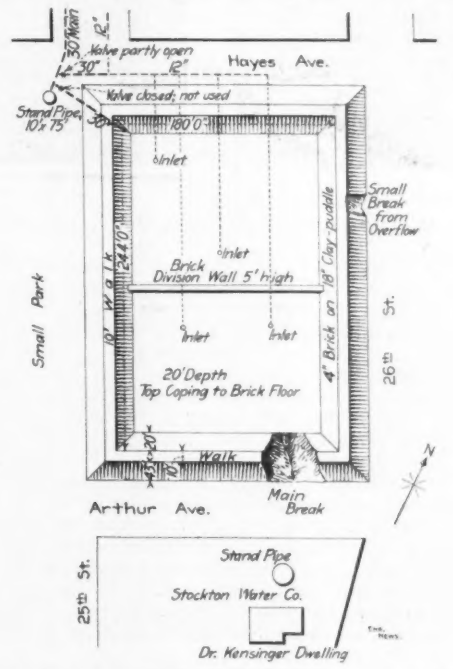
The break in the reservoir will probably be repaired; although the inhabitants of the vicinity are urgent for its removal.

Mr. F. Walter Toms is chief engineer of the water department, under the direction of the city council.

IRON OR WOODEN LOCK GATES; COSTS OF CONSTRUCTION AND MAINTENANCE

At the late International Navigation Congress, at Düsseldorf, six separate papers were presented upon the comparative cost of construction and maintenance of iron and wooden lock-gates for large canals. A general report by Mr. Fulscher, of Berlin, summarizes five of these reports, and from this summary the following points are gathered.

Messrs. Brandt and Hotopp, of Luneburg and Hannover, contend that economical requirements are theoretically best satisfied by minimum cost of construction; including in this cost, cost of the



Sketch Plan Showing Breaks in Reservoir Embankments at Camden, N. J.

original installation, the compound interest on a sum equivalent to cost of periodic renewal and capitalized cost of maintenance. In the summary of iron and wooden locks, in the North Sea region, the authors point out that wooden gates are only used up to 13 m. clear width of lock and 9 m. height of gate. Reckoned per sq. meter of useful surface and at the dimensions noted, the wooden gates average a cost of 160 marks, and the iron gates 200 marks; the relative cost being as 1 to 1.25. In smaller gates the comparison is more in favor of wood.

These tables show that the duration of life of the wooden gates is between 17 and 38 years; the duration of the iron gates is between 28 and 48 years. On this basis the comparative durability is placed at 25 and 40 years for the wooden and the iron gates.

In the wooden gate the strip of surface alternately exposed to air and water is destroyed first. But, in the ebb and flow district, the limits of decay lie above the average height of water and above the low-water line; generally, at one-fourth to one-third the average height of high tide. The destruction of the wood at this critical height leads to a renewal of the whole gate and shortens the duration. The iron gates, on the contrary, are first attacked on the inaccessible surface constantly under water; the rate of this destruction considerably depends upon the chemical constitution of the water, and presence of foreign matter which first destroys the paint and then oxidizes the iron.

Few data are available as to the annual cost of maintenance. The authors assume these costs at from 0.5 to 1% of the first cost of construction, basing this assumption on personal experience. On separate results given for six locks with iron gates they figure the average cost of maintenance at 0.85% of first cost; but they do not recommend the acceptance of this average for a working basis.

In summing up the authors give the advantages and disadvantages as follows: Iron gates can be more conveniently shipped without undue strains; with their double skin, they are stiffer than wooden gates; they are more readily manipulated; but, in case of damage by collisions, wooden gates are usually more rapidly and cheaply repaired than iron ones.

The authors draw the general conclusions, that for locks over 13 m. clear width and 9 m. clear useful height, the employment of wood is not in question. For locks below these dimensions, iron gates are more economical for locks from 8 to 13 m. clear width and 6 to 8 m. clear height of gate.

Mr. W. Henry Hunter, M. Inst. C. E., and Chief Engineer of the Manchester Ship Canal, deals with lock-gates of greenheart wood and of corrugated iron stiffened with angle iron; the former being used in the Manchester Canal. He finds that for an opening of 65 ft. and a depth of water of 40 ft., the wooden gates cost £8,489, and the estimate for the iron gates was £5,760; or the iron gate was about one-third cheaper than wood.

But as to duration of life, he says that it is scarcely possible to set a limit to the durability of greenheart gates. His observations showed that such gates built in 1862 and 1866 had required no repairs, and were still in excellent condition. Gates in the Liverpool docks, made 70 years ago of English oak, are also still in good condition. Mr. Hunter puts the duration of iron gates under equal conditions at 30 years. In the case of the 28 sets of gates in the Manchester Canal, the average yearly cost for repairs is £3 per pair. He admits that iron gates require less power in turning than these wooden gates; and he bases his selection of material solely upon the claimed greater durability of the greenheart.

Mr. J. Nelemans, Engineer of the Waterstaat at Ter Neuzen, gives the practice of Dutch engineers in this connection. He concludes that for lock-gates more than 18 m. wide, the use of timber, and especially oak timber, presents practical difficulties. In regard to cost of maintenance, he ranges the materials of construction as follows: Creosoted fir, iron, oak; ease of handling, creosoted fir, oak, iron, greenheart; according to duration of life, oak, creosoted fir, iron. Mr. Nelemans contends that repairs can be made more easily on iron than on wooden gates, as the renewal of a single crosspiece necessitates the dismantling of the whole wooden framework. He takes the duration of an iron gate at about 60 years; and gates of creosoted fir have done well for 40 years.

Messrs. Pierrot and Melotte, of Antwerp, treat of the gates of the Kattendyk sea-lock in Antwerp, finished in 1859. This lock is 24.8 m. wide in the clear; the gate-flaps are 13.84 m. wide, and the flood-gates 10.85 m. high and the ebb-tide gates 7.95 m. high. The wooden "crossbar" gates were built in 1856-7, with oak in all principal structural parts, and American pitch-pine in all other parts. The iron gates were made in 1871-74, and are sheathed with iron on both sides up to mean high-tide mark. The cost of these gates, per sq. m. of gate area, was 250 and 293 francs for the two kinds of wooden gates; 311 and 605 francs for the iron gates; and 361 francs for the new wooden ebb-gates of 1896-7. No report upon relative cost of maintenance is included. While some of the wooden gates were damaged by collisions and had to be replaced, the wooden gates at the upper end of the locks, put to work in 1854, were in such good condition in 1895, that it was determined to go back to wood for the lower ebb-gates.

Mr. Joly reports on the lock-gates in the great French seaports, chiefly in tabular form. He concludes as follows: For well-made gates of oak or pine, and for locks 13 to 16 m. wide, the cost of construction averages from 300 to 400 francs per sq. m. of gate surface. For inner gates the cost of maintenance amounts to about 2 francs per sq. m.; for outer gates, exposed to wave action, this sum must be doubled. Gates of greenheart are not subject to the attack of the teredo; and in cost of construction such gates are not appreciably higher than oak or pine. While the cost of maintenance is lower, iron gates with vertical posts are recommended for large openings where the flaps are considerably wider than the height of the gate; otherwise, iron gates with horizontal girders are to be preferred. In locks 21 m. wide the cost of an iron gate of the upright type is about 400 francs per sq. m. of gate; for the girder type, in same lock, the price would be 400 to 500 francs. He advises galvanizing iron gates, which increases the cost about 10%. He puts the average annual cost of maintenance at 3 francs per sq. m. of gate, for medium-sized gates, and 4 francs for large gates. He estimates the life of an oak or pine gate at 25 years; and 35 to 40 years for galvanized iron gates.

Mr. W. W. Squire, M. Inst. C. E., and Engineer of the Bristol Docks, presented a paper upon the construction and working of lock-gates with reference to repairs and maintenance. Mr. Squire says that of all timber gates greenheart offers the best resistance to the ravages of the teredo; but it is by no means invulnerable. In the Bombay Docks greenheart is freely attacked by these animals. He goes on to point out the necessity of means to remove and repair any type of gate; and after discussing various methods of so doing he shows photographic views of slings and cranes for lifting gates bodily out of the water, and gives directions for handling these appliances.

FIG. 1. THE BREAK WELL UNDER WAY.

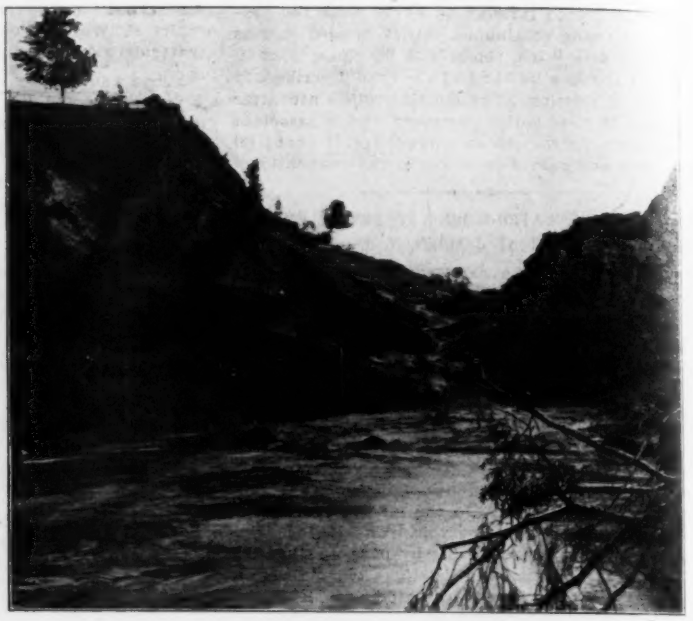


FIG. 2. THE BREAK PRACTICALLY COMPLETED.

VIEWS OF THE RECENT BREAK IN THE UTICA WATER-WORKS DAM.

THE FAILURE OF THE WATER-WORKS DAM AT UTICA, N. Y.

The unique failure of the dam forming Reservoir No. 3 of the Consolidated Water Co., of Utica, N. Y., was described briefly in our issue of Sept. 25. Since then Mr. Wm. S. Bacot, Engineer and General Manager of the company, has kindly sent us some particulars of the accident, and also a number of photographs taken during and since the failure. Some of the views are reproduced herewith. Fig. 1 shows the work of destruction in progress, and Fig. 2 the break completed, both from below. Fig. 3 is a general view of the break from above, but is designed to show more particularly the wreck of the inner portion of the whole embankment. The deformation of the latter may be traced more readily on remembering that the paved slope, shown in the view, was once horizontal at its upper edge. Figs. 4 and 5 show the deformation in more detail.

Mr. Bacot's account of the failure and comments thereon are as follows:

The dam was 70 ft. high; top width, 15 ft.; inner slope, 2 to 1; outer slope, 1½ to 1. The failure of the dam was undoubtedly due to the weak material used in the upper 20 to 25 ft. at the north end of the dam. This material was slightly better than sand, and the wonder is that it remained in place for so many years without slipping away.

Immediately after the first landslide, which carried about two-thirds of the distance up the bank, seepage was disclosed at certain points located generally in a line about 20 ft. below the top of the dam. These seepage points seemed to mark the place where the pervious overlaid the impervious material.

The outer slope of the dam seemed to be formed of this same light substance. For some years after the dam was constructed, small slips occurred at various points of the embankment, caused, I think, by this unstable material. The original plan of the dam called for a core reaching about 35 ft. from the bottom, but practically all the lower section of the dam was of dense and stable material.

The whole fault lay in the upper part of the north end. There was no leakage whatever, at the base of the dam, or at any point in the lower two-thirds of the embankment.

The collapse of the inside of the embankment after the break seems to indicate that the slope of 1 on 2 in high embankments is not a safe rule to follow. This may not be the case with all classes of material, however. At all events, I should prefer to break the inner slope with benches should it ever fall to my lot to construct an embankment of such height. I should also deem it wise to make the outer slope 1 on 2, instead of 1 on 1½.

The special feature of this failure is the collapse (mentioned above—Ed.) of what was left of the embankment, immediately after the water flowed from the reservoir. The whole dam is now a total wreck.

The collapse mentioned in the last paragraph, as we learn from an eminent engineer who has visited the dam since the failure, consists of the slumping down of the inner or wet portion of the dam, so as to materially flatten the upper slope and leave a pronounced crack, or series of cracks, along the whole, or nearly the whole, crest.

From the same engineer we have secured the

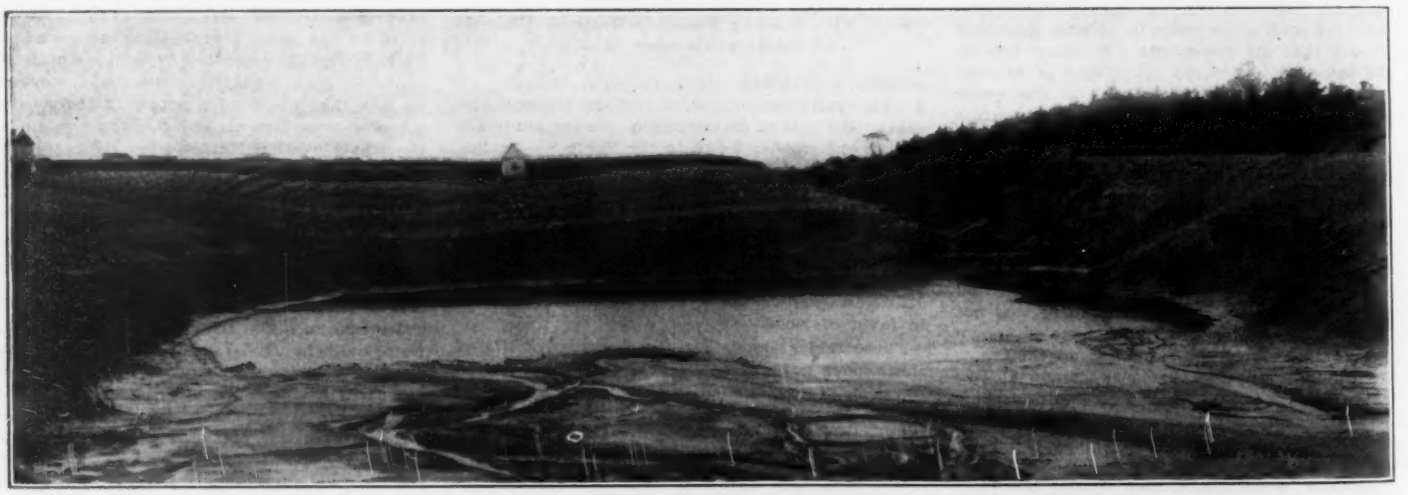


FIG. 3. VIEW SHOWING SLUMP OF INNER SLOPE OF UTICA DAM AFTER PART OF EMBANKMENT WENT OUT.

following additional information: The foundation was a good hardpan, but stumps and roots on the original bank indicate that there was no stripping. The material composing the lower portion of the embankment, so far as seen, appears to have been good, but the upper portion was composed of light, sandy loam. A man who was on the dam when it was built states that there was no rolling and very little wetting, and that some of the material was put in by means of wheelbarrows, thus not having even the advantage due to the packing caused by horses and carts. As evidence that the material was not well compacted, it is stated that during three years after construction the crest of the dam settled some 3 ft.

The inner slope was covered with hand-placed field stones, laid dry. There was no core-wall. A 20-in. discharge and a 20-in. waste pipe were the only means of drawing off the water from the reservoir.

In addition to the foregoing it may be stated that the dam was built in 1873, and that, so far as we can learn, no engineer was employed on its design or construction. The original water-works came under the control of the Consolidated Water Co. not long ago, so that neither the present company nor its engineer is in any way responsible for the design of the structure.

THINNING OUT TREES ON CITY STREETS and lots as a means of affording fuel to relieve possible suffering during the coal strike has been suggested by Mr. Olin L. Jenkins, Mayor of Plainfield, N. J., and the following resolutions have been adopted by the city council:

Resolved, That the Committee on Lights and Trees be authorized to confer with property owners with respect to the matter of selecting trees which can be advantageously removed from streets or lots, and in case the wood from said trees is not desired by the property owners, and shall be donated to the city, the committee is authorized to employ laborers to cut down and prepare for use such trees as may be so donated.

Resolved, That said committee be authorized to sell the wood so obtained to such persons on such terms and in such quantities as shall, in their opinion, serve to accomplish the greatest relief, all moneys received to be applied toward the expenses incurred in the premises.

The sum of $300 has been appropriated to carry on the work. We are indebted to Mr. A. J. Gavett, City Engineer of Plainfield, for the above information.

THE RAILWAYS OF NEW SOUTH WALES, Australia, aggregate 3,026 miles in length, according to the report of the Railway Commissioners for the year ending June 30, 1902. During the year 187 miles of new line were opened, and the capital cost for the total mileage amounted to $202,825,365, or $67,035 per mile. Seven pioneer lines are now under construction, aggregating 422 miles in length. The absolute block system is in use on 1,314 miles of line, and progress is being made in the interlocking of switches and signals. Rails of 80 and 100 lbs. per yd. are being laid to replace others of 70 and 75 lbs. per yd.; grade improvements are in progress, and the duplication of the main Western line over the Blue Mountains is nearing completion. At Darling Harbor a steel warehouse 850 × 91 ft. is being erected, and will be equipped with hydraulic cranes and other loading facilities, while at Darling Harbor a large warehouse has been erected and equipped with electrical appliances for conveying bags of wheat into the shed and loading them into ships or railway cars. There are 518 locomotives, 1,073 cars in passenger service, 11,183 cars in freight service, and 1,052 in railway service. The gross earnings were $18,343,430, or $6,295 per mile, while the operating expenses absorbed 61.8% of the gross earnings. The earnings and operating expenses per train mile were $1.57 and 97 cts., respectively. There were 13,158,336 passengers carried, or 27,404,397 passenger journeys, including the journeys of workmen and season-ticket holders. No train accidents occurred which involved loss of life. The government also owns and operates 104 miles of steam and electric street car lines in Sydney and its suburbs, and 21 miles are under construction. The operating expenses of these lines absorb 85.79% of the gross earnings. Mr. Charles Oliver is Chief Commissioner; Mr. W. Thow, Chief Mechanical Engineer; Mr. Thomas R. Firth, Engineer in Chief for Existing Lines, and Mr. G. R. Cowdery, Engineer of Tramways.

A CIVIL SERVICE EXAMINATION in lieu of the examination noted in Engineering News of Oct. 2, 1902, will be held on the same date for the positions of Irrigation Engineer and Assistant Engineer or Hydrographer in the U. S. Geological Survey. The examination will consist of the subjects mentioned below, which will be weighted as follows: (1) Mathematics (algebra, including quadratics, plane and solid geometry, and plane trigonometry), 10; (2) physical geography of the United States, 5; (3) topographic sketching and lettering, 5; (4) topographic United States and general surveying, 10; (5) hydrographic methods, 20; (6) discussion of hydrographic data, 15; (7) training and experience, 35. Two days of seven hours each will be required. The first four subjects will be given on the first day and the remaining subjects on the second day. Age limit, 20 years or over. From the eligibles resulting from this examination it is expected that certification will be made to the positions of irrigation engineer and assistant engineer or hydrographer in the Geological Survey, at a salary of $1,000 to $2,000 per annum, according to experience and results of examination, and to other similar vacancies as they may occur. This examination is open to all citizens of the United States who comply with the requirements. Competitors will be rated without regard to any consideration other than the qualifications shown in their examination papers, and eligibles will be certified strictly in accordance with the Civil Service law and rules. Persons who desire to compete should at once apply to the United States Civil Service Commission, Washington, D. C., for application forms 304 and 375. Persons who are unable to file their formal applications and who notify the Commission of this fact, either by letter or telegraph, with the request that they be permitted to take the examination, will be examined, provided their requests are received at the Commission in sufficient time to ship examination papers.

CIVIL SERVICE EXAMINATIONS for an eligible list for filling 14 vacancies as Aid in the U. S. Coast and Geodetic Survey will be held beginning Oct. 21, 1902, at various cities in the United States. The examination will consist of the subjects mentioned below, which will be weighted as follows: (1) Mathematics, including the elements of calculus, 10; (2) practical computations, 10; (3) astronomy, including the determination of latitude, longitude, and azimuth with portable instruments, 10; (4) physics, including the elements of optics and magnetism, 10; (5) surveying, including topography, triangulation, and the use of ordinary field instruments, 10; (6) modern languages, translation into English from one European language, 10; (7) drawing and descriptive geometry to and including projections, 10; (8) training and experience, 10; (9) physical examination, to be rated, 20. The examination will be divided as follows: First day, 7 hours, first three subjects; second day, 7 hours, remaining subjects; age limit, 18 to 25 years. The character and prospects of the position of Aid are explained by Mr. O. H. Tittmann, Superintendent U. S. Coast and Geodetic Survey, as follows:

From the eligibles resulting from this examination it is expected that certification will be made to fill 14 vacancies in the position of aid in the Coast and Geodetic Survey, at a salary of $720 per annum each, and to other similar vacancies as they may occur. This examination is open to all citizens of the United States who comply with the requirements. Competitors will be rated without regard to any consideration other than the qualifications shown in their examination papers, and eligibles will be certified strictly in accordance with the Civil Service law and rules. Persons who desire to enter this examination should at once apply to the United States Civil Service Commission, Washington, D. C., or to the secretary of local board of examiners for application forms 304 and 375, which should be properly executed and promptly filed with the Commission at Washington. The medical certificate in application form 304 must be executed. Persons who are unable to file their applications, but whose requests are received at the Commission in sufficient time to ship examination papers to the places selected, will be examined.

The rank of aid is the lowest or entering rank leading to the position of assistant to the superintendent. The Coast and Geodetic Survey is engaged in a great variety of duties and its operations extend over a vast range of territory. The aids, like the assistants, are subject to assignment either as chiefs of party or subordinate officers on parties engaged in the determination of the magnetic elements, in secondary triangulation and astronomical determinations for the control of topographic and hydrographic surveys, in primary triangulation and the corresponding astronomical determinations, in topographic surveying along the coast and in hydrographic surveys in the bays or harbors and in the open sea. The steamers and sailing vessels belonging to the survey are commanded by these members of the permanent field force. During the intervals between field seasons assistants and aids are subject to assignments to office duty in Washington, or in one of the sub-offices at Seattle, San Francisco, Honolulu, or Manila. Nearly all administrative positions in the office at Washington, from that of chief of division to the highest rank, are open to and are now filled by assistants. The duties of the field officers take them to all parts of the United States, including Porto Rico, Alaska, Hawaii, and the Philippines. The members of the permanent field force have, therefore, a very wide range of duties as surveyors engaged in the highest grades of surveying, as navigators and as scientists, and have a rare opportunity for extensive travel and acquaintance with the world. The aid is subject to assignment to any duty required of any other officers of the permanent field force. In general the exigencies of the Service place the aids so promptly in responsible positions that there is an abundant opportunity for a man of exceptional ability to become known. Aids are appointed at a salary of $720 per year. The next step in the line of promotion is to the salary of $900 as aid, and thence to assistant at $1,200, and then upwards by steps of $200 each. These statements of salary are misleading unless taken in connection with the fact that necessary traveling expenses incurred in the line of duty are paid by the government, and that in addition to his salary he is paid an allowance for subsistence to cover the ordinary living expenses while on field duty. During this period the allowance for subsistence is from $1 a day for an officer living on shipboard or in camp in quarters furnished by the government, to $2.50 a day for a chief of party living at a hotel or other quarters not furnished by the government. All appointments to the position of aid are made from a Civil Service examination.

FIG. 4. VIEW OF BREAK FROM ABOVE.

FIG. 5. DETAILED VIEW SHOWING DEFORMATION OF TOP OF REMAINING PART OF EMBANKMENT.

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An additional water supply for Greater New York is imperative, but year after year goes by with no definite action to that end. True, the notorious Ramapo scheme suddenly loomed on the water horizon a few years ago, and two valuable reports were made in connection with the worthy and successful efforts to scotch that serpent. The situation in that part of the city located on Long Island has been kept well in hand by the Brooklyn engineers for years past, and there would be little or no water problem there at present if these engineers had been given authority to execute their plans. Delays, however, have left Brooklyn in a particularly dangerous condition, and it now seems desirable to at least consider its needs jointly with those of the whole city. As the case now stands, the water problem of the Greater New York needs to be given immediate and thorough study under the auspices of the city government as a whole, rather than under the direction of borough officials, or even the Department of Water Supply, Gas and Electricity itself. It seems particularly fitting, therefore, that Controller Grout, representing the financial side of the administration, should urge upon Mayor Low the appointment of a commission of three eminent engineers, with the present Commissioner of Water Supply, Gas and Electricity as chairman, ex-officio, to inquire into

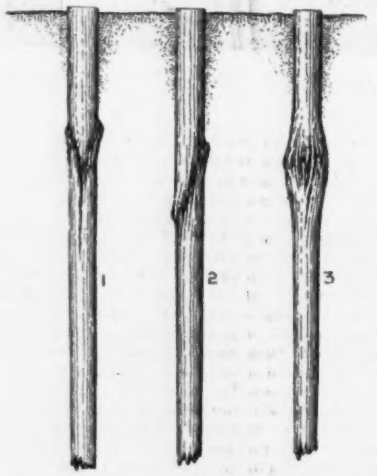
(1) The best source of supply for the immediate and distant future; (2) the most desirable method of procedure in order that the best results may be obtained at the earliest possible time; (3) the changes necessary to the existing system, which should be carried on simultaneously with the new work; (4) the probable cost during each succeeding year as the work progresses; and the commission to be instructed to report by Jan. 1 next, at which time it shall cease to exist.

It is also suggested, and wisely, that Mr. John R. Freeman, M. Am. Soc. C. E., be secured, if possible, as a member of the commission in order to have the benefit of the knowledge gained by him in his recent investigations. The second engineer, Mr. Grout suggests, might be named by the Merchants' Association, which has already taken so much interest and expended such large sums of money in behalf of the future water supply of the city. The two men thus secured would name the third engineer member of the commission. It will be noticed that a permanent commission is not proposed, but one designed to clear the way, so to speak, for a more detailed and definite solution of the problem. Action, and that at once, is imperative, since months of preliminary inquiry are needed before the necessary years of engineering study and construction can be entered upon.

We again call attention to the important matter of the safe limit of fall in pile driving, which was raised in our issue of Sept. 25, and is further discussed in our department of "Letters to the Editor" in this issue. One of the contributors to the discussion, we may note, is a well-known member of the American Society of Civil Engineers, who has had over thirty years' experience in engineering work.

As we said two weeks ago, engineering literature is notably deficient in information on this subject. Incidental reference occurs, indeed, in the voluminous discussion on the bearing power of piles, to the fact that the pile must not be broken by over-driving if the formulas—and the piles—are to hold; but direct information as to the manner of failure and the limit of safe driving is scarce indeed.

Doubtless, one reason for the lack of attention to this subject is that a pile once driven is buried from sight and its condition is never known save in rare cases where the pile is pulled up or the ground around it is excavated. One such instance was related by the late Robert L. Harris in a letter published in Engineering News nearly ten years ago (Dec. 8, 1892). In 1879 he was in charge of construction on the Boston, Hoosac Tunnel & Western Ry., and temporary bents of piles were driven to a depth of about 22 ft. at two points where the line passed under embankments of the Troy & Greenfield Ry. The embankments were of fine compact sand, and the piles drove hard and slowly. When the earth was excavated it was found that over half the piles were next to worthless, being split or broken at a considerable depth below the surface in one of the three ways shown in the accompanying cut. Most



Modes of Failure of Over-Driven Piles.

of the piles failed as shown in (1), but there were a number which failed, as in (2), and very few which broomed out all around as in (3).

Another case of the failure of piles occurred many years ago on work in charge of a member of the editorial staff of this journal. A foundation had to be made with limited funds—particularly for engineering investigations—in a soil composed of soft mud interspersed with horizontal layers of gravel hard-pan of varying thickness. In default of better methods, it was determined to drive piles so hard that it could be safely concluded that they were resting on a stratum thick enough to carry the load. When it was attempted to put this into practice, however, it was found that the piles were smashed by the heavy driving. Ordinary spruce, pine or hemlock, and even oak would split and smash when it was attempted to drive them to the extent desired. Finally, however, some piles were obtained of Nova Scotia spruce full of live knots, and so tough that they defied every attempt to split them, while the wood was soft and elastic enough to absorb the blow of the hammer. With these piles a satisfactory foundation was made.

We cite the above cases as evidence that piles can be and frequently are crippled, and their supporting power seriously curtailed by the heavy driving which is frequently required in conformity with the letter of specifications. Accepting the fact that piles are so crippled, ought not this fact to be recognized in specifications? Ought not limits of safe driving to be fixed by the engineer who has regard for the safety of the structure to be supported? Ought not heavy hammers and low falls to be used, rather than lighter hammers with high falls? These and similar questions we submit to our readers, and trust that information concerning them may be forthcoming.

The failure of a reservoir at Camden, N. J., last week, might have been averted, we judge, had the city installed and maintained in good working order so simple and inexpensive a device as an automatic shut-off valve; or an even simpler and cheaper high water alarm would probably have prevented the accident. As it was, it appears that the city did not even safeguard its property and its citizens by a watchman's clock, and an important valve was left where any one could tamper with it at will. The water-works at Camden, it may be added, are controlled by the city council, through a chief (pumping?) engineer. For all we know, the council may have been urged again and again to provide more efficient means of safeguarding its water-works property; but whether it has or has not, its reservoir is now a partial ruin through apparent if not real neglect.

THE CONSTRUCTION AND MAINTENANCE OF RAILWAY EMBANKMENTS.

The settlement of railway embankments is a frequent source of trouble and anxiety to engineers, and a source of expense in repairs. Much of this trouble is due to the haphazard way in which such embankments are usually built, with various kinds of materials indiscriminately dumped in. In many cases, also, only a very superficial examination is made of the ground on which the bank is to be built, and after completion settlement commences and sometimes continues almost indefinitely. In one recent case a bank that was estimated to require 600 car loads of material required over 2,000 car loads before it was stable.

The present practice is very generally forced upon engineers by the necessity for rushing work ordered by the higher officers, but it is in many cases a very uneconomical method of working, since it may, and often does, involve very expensive and troublesome work in the future, and sometimes proves a cause of fatal accident. Many of our readers will recall the disaster at Garrison's, N. Y., on the New York Central & Hudson River R. R., in 1897, where an embankment slid into the river as a fast express train was passing over it, and 20 passengers lost their lives.

Another fatal accident which occurred last spring on a railway in Ohio was described as follows in a letter to this journal:

The accident which occurred in the yards of the —— Ry. Co. was caused by a dirt fill roadbed being built over running springs, without drainage or proper filling to hold tracks up. The tracks were only built three years ago by Mr. ——, superintendent of the division (son of the President of the road). The fast mail train was coming into the city on the second track from the edge, and running at the rate of 35 miles an hour. The upper crust of the embankment was perfectly hard and looked all right, but the under part, being spongy, squashed out, and hurled the engine and first four cars into the gully beside the tracks and 30 ft. below. The engine broke loose from the next car, and turned over

running under it the engineer and fireman, both of whom were killed. Three mail clerks were seriously hurt. One of the remarkable features of the disaster was, that the unsupported rails after the train had left the track, sprang half-way back into position, and in one place extended across the chasm, making it look as though the train by some magic had dropped between the ties. Had the passenger train which follows the mail train been the one to go in the ditch, the death list would have totaled nearly one hundred. The roadbed is now being filled with large rip-rap, and the water is running between the stones from springs under the tracks. This seems pretty shabby twentieth century engineering, especially in such a place as the large ——— railroad yards.

In view of such occurrences as these, it certainly cannot be denied that the character of railway embankments is a matter of much importance to the railway manager and the railway engineer. It is quite probable, too, that the need for care in building railway embankments is much greater now than it was a few years ago. The fast and heavy trains now common in railway service must bring stresses to bear on railway embankments far greater than those which were formerly experienced.

We believe that progressive engineers are paying more attention to this matter; yet the general rule, it must be confessed, either on new construction or in trestle-filling or bank-widening on existing lines is to use whatever material lies most convenient, and to dump it hit-or-miss as it comes.

On one railway line recently brought to our attention some banks were built by dumping from a temporary trestle trainloads of material excavated by steam shovels at two different points, each of which developed a variety of materials. In the banks under construction there were plainly distinguishable sections, pockets and layers of earth, clay, coarse gravel and fine gravel or sand. The mixture and indiscriminate arrangement of the materials have probably been potent causes in the slipping and settlement of some of these banks, which has necessitated continual work in dumping material and raising the track. In one particularly bad case much of the material was a "gravel" composed of very fine shifting sand mixed with smooth round stones. With the heavy rains of the past season, the sand flowed like water, and the slopes were gullied so deeply that the ends of many of the ties were left unsupported, while the sand formed in horizontal beds on the right of way. New and better material since dumped upon the bank does not get a proper bond with the older material, and the slipping, washing and gullying still continue.

The regular practice in English railway construction is to trim embankment slopes, cover them with good soil, and then either face them with sods or sow grass seed. Some progressive American engineers have advocated a similar practice in this country, among whom may be mentioned Mr. D. J. Whittemore, M. Am. Soc. C. E., Chief Engineer of the Chicago, Milwaukee & St. Paul Ry., who some years ago read a paper on this subject before the American Society of Civil Engineers. It is not probable that so complete or expensive a system could be generally followed in this country, although much might be done for the permanent improvement of banks and slopes of cuttings on existing main lines. A certain amount of such work is, of course, being done; but it would probably be carried to a greater extent if its economical value were more generally recognized. This economy comes from the fact that a somewhat heavy expenditure on really permanent work may eliminate the constant expenditures for materials and labor in widening banks, repairing slopes, etc. The gravel train expenses for work of this character are apt to be heavy, and the work usually involves more or less interference with traffic.

In some cases settlement is caused not by the settling or washing away of the material in the bank itself, but by the compression of the earth upon which the bank is built. Where the ground is swampy or known to be soft, investigation should be made as to its depth, quality, bearing power, etc., and the possibility of improvement by preliminary drainage. Such investigation may even show the economic desirability of a change in location. It is not always the case, of course, that apparent conditions will warrant the time and expense of special investigation of the embankment sites, and it would be impracticable to make such investigations for every bank. Yet banks built on apparently stable ground are sometimes the ones that give trouble. Thus on one part of the Chicago & Northwestern Ry. the line was located on embankment across a piece of timbered land on which were growing trees some 18 ins. in diameter. These with other conditions offered apparent evidence of stability, and there was no suspicion or expectation of trouble. After the line had been built and in operation for some time, however, the bank began to go down and no amount of filling would make it permanent. On investigation it was found that there was a "crust" of earth 10 ft. thick, underlaid by soft mud, and the load and vibration of the embankment had broken through this crust. Piles 90 ft. long were driven without striking bottom, and neither piling nor cribbing availed to make a substantial roadbed. It was eventually decided, therefore, that it would be more economical to stop the continual expense for keeping this part of the line in condition, and build a diversion on a location where a firm foundation could be assured.

Conditions of this kind occur in many parts of the country where "sink holes" exist, and one such case was described and illustrated in our issue of March 27, 1902. The sinking of the bank in such cases is usually accompanied by a rising or swelling of the ground on either side, at a distance varying with the kind of material, etc. Sometimes the sinking may then be checked by loading the surface along these swells or ridges, and thus restoring the equilibrium.

Railway embankments are as a rule built by dumping from the ends or from a temporary trestle, a narrow bank being built at first and then widened out by side dumping. It is rarely that a bank is built up the full width from the ends. On very large banks an excess of material is sometimes used to give a width that will allow for gullying by the rains before the bank has become consolidated. In some cases banks of 40 to 50 ft. width on top have been built for this purpose, and it will be seen that an enormous amount of material had to be excavated and handled in excess of the most liberal allowance for a bank of proper dimensions. We do not know whether any estimates were made as to the comparative economy of a bank of net section with protected slopes or a bank of gross section built with the intention of letting large quantities of material be washed away to waste.

The idea is often expressed that while it would be very desirable to have a uniform quality of material in an embankment, this is a practical impossibility owing to the exigencies of construction. The suggestion of building a railway embankment in horizontal layers, like a dam, is also commonly regarded as utterly impracticable, but we know of at least one case in which this method was followed with very satisfactory results. In filling in a long iron trestle with a bank about 65 ft. high, on the Chicago & Northwestern Ry., the material was dumped in the usual way from cars on the trestle, but instead of being allowed to accumulate and widen from the sides, drag scrapers and teams were used to spread the material over the whole width, slope stakes being set on the completed work as it was carried up. The surface was kept slightly crowned so as to shed water. In this way the bank was built in horizontal layers, and the cost was very slightly in excess of that for the ordinary method, while there has been no expense for extra maintenance work. In other banks, built in the same neighborhood and at the same time, but by the ordinary method, the material has settled and slid, and additional material has had to be dumped in large quantities.

One cause of the slipping of the slopes of banks is the method employed for filling in where the bank has settled. The settlement often occurs along the middle of the top of the bank, which becomes concave or hollow. This depression is filled in again and again, but serves to collect and hold water which saturates the bank and eventually causes the side to slip or "blow out." In many cases this action might be prevented by cutting away the edges of the bank to the level of the depression and then applying the new material over the whole width of the top of the bank.

Where existing embankments have to be widened to give a proper width for roadbed, the common practice is to simply dump material down the slope, with the result that large quantities slip or are washed away. We have in mind a case of this kind, where a double track bank was widened about 2 ft. on each side, but no attention was paid to getting a bond between the new and old material, although the slopes were hard and smooth. In a very short time long cracks appeared along the edge of the old bank, and then great masses of the new material slid away, leaving the old slope exposed.

This subject was discussed in a very liberal and far-sighted way in the report presented by the Committee on Grading at the second annual convention of the American Railway Engineering and Maintenance-of-Way Association in 1901. The report, which was printed in our issue of March 14, 1901, advocated a closer investigation of the soils during location, and of the ground at embankment sites previous to construction. The importance of homogeneity in the mass of a bank was pointed out, and the recommendations for good work included the building of embankments in horizontal layers of about 3 ft. in thickness. There were not a few members at that meeting who regarded the report as utterly impracticable, and there was some little sarcasm in reference to nickel-plated earthwork. On the other hand, several members endorsed the report, and described their own experiences of material and money wasted in the continual repair and improvement of work improperly constructed in the first place.

Where an engineer has not a free hand in carrying out work of this kind, he will generally have to face considerable opposition, owing to the common idea that nothing more is required than the mere dumping of material of any sort in any way. In many cases he may prefer to follow the old custom rather than get the reputation of being impracticable, wasteful or "cranky." But it is possible that by careful estimates and an analysis of work-train expenses he might be able to show that time and substantial economy may be effected by newer and better methods: (1) the more careful examination of bank sites and provision for good drainage; (2) the hauling of good material from a distance instead of using a poor material close at hand; (3) the use of a proper amount of material in a proper way instead of an excess of material which will largely be wasted; (4) the construction of a bank in the same way as a dam; or (5) the protection of slopes of both banks and cuttings. It should be possible to show in many cases the great amount of gravel-train work annually required upon certain banks, and the continual drain in expense which such work involves, as compared with a single expenditure for better and more permanent work in the first place.

LETTERS TO THE EDITOR.

Calculating Columns Under Eccentric Loads.

Sir: In answer to the communication under the above caption in your issue of Sept. 25, a very good method for designing columns with concentric and eccentric loadings will be found in the 1900 edition of Professor Johnson's "Modern Framed Structures," p. 453.

In brief, the column should be designed to carry the total of all loads, both concentric and eccentric, and enough excess area added to take care of the bending moment due to the eccentric load.

The equation given by the correspondent last week is Professor Johnson's equation (10), p. 453, written in a different form. Yours truly,

C. W. J. Neville,

6032 Kimbark Ave., Chicago, Ill., Sept. 29, 1902.

Shrinkage of Embankments.

Sir: Will you kindly answer the following query in your valuable publication: Given an embankment, constructed of a light, loamy soil; solid contents 240,158 cu. yds.; length 8,400 ft.; height varying according to contour of surface from nothing at initial points to 33 ft.; breadth varying from 16 ft. to 205 ft. at base, and of a uniform breadth of 16 ft. at top; upstream slope 3 to 1; downstream slope 2 to 1; work commenced in March, 1900, and completed in February, 1902, at which time the measure-

ment was taken; embankment built up in layers of from 12 to 18 ins. in thickness and compacted by driving over same with teams and wheel scrapers, etc.; how many cubic yards of excavation required to build said embankment?

In other words, would the work done measured in the excavation show more or less, in cubic yards, than solid contents of embankment, and how much?

Very truly yours, W. H. Herdman.

Omaha, Neb., Sept. 25, 1902.

(According to the experiments of E. Morris made some 60 years ago on extensive railway embankments, the shrinkage of loamy soil taken from a "cut" and compacted in a "fill" was about 15%. Earthwork under the conditions above enumerated always shows a greater yardage measured in place than in embankment. Some interesting data on this subject are to be found in our issue of July 10, 1902, in an article on the Tabeaud Dam, wherein it is stated that the weight of a cubic foot of the natural gravelly soil in place was 116.5 lbs., and packed in the embankment it was 133 lbs. Since it is impossible to state what the exact shrinkage will be in any case, we would suggest the advisability of digging a small test pit of measured dimensions in the natural soil, and another in the finished embankment, and by weighing the material excavated from each pit a very close estimate of the actual shrinkage can be made.

For further printed information relative to earth shrinkage reference may be made to "Letters to the Editor," published in our issues of Nov. 15, Nov. 22, Dec. 13, and Dec. 20, 1900, also Jan. 10, 1901.—Ed.)

Turbines Used by the Michigan-Lake Superior Power Co.

Sir: Your issue of Sept. 25 contains an illustrated article on the water-power development at Sault Ste. Marie, Michigan. We beg to call your attention to a statement made by you in this article, namely: "Each hydraulic unit is made up of four 33-in. 'New American' turbines arranged in two pairs on one shaft."

The turbines in question are "Jolly-McCormick" turbines, furnished by the Webster, Camp & Lane Co. The turbine known as the "New American" turbine is built by a company in Dayton, Ohio, and has nothing in common with the "Jolly-McCormick" turbine, which is built from the original "McCormick" patterns owned and manipulated by J. & W. Jolly, of Holyoke, Mass.

Thinking that you would not allow a misstatement to stand, we have ventured to call your attention to the facts, as above stated. We have furnished the Michigan-Lake Superior Power Co. up to date 168 of these turbines, being the largest number of turbines ever built for one power plant. We believe that these turbines hold a record that has never been equalled in power, speed and efficiency, when tested in horizontal settings. We enclose a copy of the record of the tests made at the Holyoke testing flume.

Yours truly, The Webster, Camp & Lane Co.

Akron, O., Sept. 30, 1902.

(The information from which our article was prepared was furnished to us direct by the Chief Engineer of the power company, and the mistake in giving the name of the turbine was probably a slip of the pen, as other information furnished us gave the above firm as the contractors for the turbines.

We may note in addition that the engineers of the Michigan-Lake Superior Power Co demanded a turbine unit which would develop 568 HP. from 391 cu. ft. of water per second, under 16-ft. head, with a turbine speed of 180 r. p. m. Also the installation must show at least 80% efficiency from three-fourths to full gate.

The turbines were tested in pairs on horizontal shaft, in the cases and settings designed for the "Soo" plant, and the tests were made in the testing flume of the Holyoke Water Power Co., Holyoke, Mass. The maximum readings shown were 292 HP, and 84% efficiency; speed, 180 r. p. m., under 16-ft. head; "Holyoke test," aggregating 584 HP. at minimum of 82% efficiency from three-fourths to full gate, for the penstock unit.—Ed.)

The Effect of Small Canals on Railway Freight Rates.

Sir: Referring to your editorial comment in your issue of Sept. 4, 1902, in regard to the Hennepin Canal, and the quotation from the address of Mr. James A. Seddon, I desire to call your attention to a map inclosed herewith, showing freight rates as affected by the Illinois and Michigan Canal, within and without a radius of 100 miles from Chicago. The map was prepared to present to the appropriation committees of the state legislature, and intended to show the value of the Illinois and Michigan Canal, to the farmers and shippers of the state of Illinois, and its effect upon freight rates.

I doubt if any candid person, after careful study of the freight rates as shown on this map, can say that the Illinois and Michigan Canal is obsolete. It is estimated that the saving to the farmers upon the three principal grain items in freight rates amounted to $1,500,000 during the preceding year. It is not necessary to defend the policy of Congress in ordering the construction of the Illinois and Mississippi Canal, commonly known as the Hennepin Canal. If, however, its construction affects freight rates in a similar manner through to, and along a reasonable length of the Mississippi River, its cost will be amply repaid.

The state of Iowa annually produces about 300,000,000 bushels of corn. A lessening of freight rates of 1 ct. per bushel upon the item of corn alone for the state of Iowa alone, would be ample compensation for the construction of the Hennepin Canal. Very respectfully yours,

L. L. Wheeler, Assistant Engineer.

Sterling, Ill., Sept. 19, 1902.

(We regret that the map sent is not susceptible of reproduction within reasonable limits of space. It shows, however, that the railway freight rates to Chicago were considerably less from points on or close to the Illinois & Michigan canal than from points equally distant, but out of reach of the canal. The map is not dated, and there is nothing to show when the rates which it shows were in force. While the map is put forth to show the benefits of the canal to the grain shipper, it really shows, it seems to us, that its benefits are confined to a narrow strip of territory adjacent to the canal. The canal can present effective competition where it reaches within wagon hauling distance of the shipper; but freight is not and will not be brought by rail to the canal. If it is once loaded into a car, it will travel by rail all the way to its destination. If the Hennepin canal could effectively compete with the railways in hauling the Iowa corn crop to market, it might be a great benefit to the shippers; but only the handful of Iowa farmers who can haul their corn to a steamboat landing on the Mississippi could benefit by such a canal.

Even if our correspondent's claim were correct, however, it would be contrary to sound political economy to build a canal on such a basis, provided existing transportation lines are capable of carrying the traffic. The railway is a natural monopoly, and should be treated as such. Attempts to regulate its charges by creating competing transportation lines can have only temporary success. The only permanent and sound plan of relief from abuse of the monopoly is through State control.—Ed.)

An Object Lesson on Earth Dams; and a Suggestion for Legislative Action.

Sir: The description given in your issue of Sept. 25 of the progressive stages by which the final destruction of a dam at Utica, N. Y., was accomplished, merits the serious consideration of those who still recommend or at least tolerate, the class of hydraulic structures to which this dam belonged.

From the accounts, it consisted of a simple earth embankment, 70 ft. high, without masonry center wall. Whether it possessed that ambiguous feature, vaguely named a "puddle wall," which may mean anything or nothing, I do not see stated. Water seems to have at first percolated through the bank, causing a "landslide" from the foot of the outer slope, and extending halfway up the bank. Next day another landslide occurred, and cracks appeared along the top. On the following morning, part of the top fell in from time to time, in detached masses. Then water began to spout through the bank, first from one hole and then from another, until a heavy and constantly increasing stream poured through a widening gap, and finally a "thorough cut" 100 or 150 ft. wide was formed through which the reservoir emptied itself. Two days seem to have been consumed in the work of destruction, during which time all available outlets were opened in the vain endeavor to relieve the reservoir before the dam was breached.

The embankment does not seem to have been overtopped at any time, and it is evident that it would have taken very little to prevent the first percolation through the bank which was the initial step in the work of destruction. A very simple precaution would have prevented this percolation, but without this precaution, when once the percolation commenced, nothing could stop it. Whether or no there was rock sufficiently near the surface to afford a sure foundation and side anchorage for a masonry center wall, there is no doubt that such a wall properly designed to meet the local conditions, would have saved the Utica dam.

An earth embankment provided with a heavy masonry center wall carried down to a firm substratum, regardless of that possibility to a considerable depth below the surface, the depth being in inverse ratio to the compactness of the material, and well bonded into the sides of the valley, forms one of the best and safest dams which can be built. An earth embankment without such wall is one of the worst and most unsafe. That there are many such dams which have not, so far, gone out, is a poor argument in favor of a faulty construction. Their presence is a constant menace to the territory lying below them.

The "puddle wall," of which mention is so often made, is a very poor palliative; clay and sand are by no means substitutes for hydraulic masonry. Moreover their proper construction is not understood in this country. It is true that a masonry wall adds considerably to the cost of an earth dam, but such extra cost should be regarded merely as a premium paid for insurance. We insure against fire; why not against water?

The existence of a large impounding reservoir in a thickly populated territory is of itself a source of danger to life and property, and the building of such structures should be under the restriction of suitable building laws. At the time of the Matteawan disaster, in the fall of 1897, I endeavored to have this subject brought before the New York legislature, but the bill which I proposed was never, as far is I know, presented. It was as follows:

Any person or persons, company or corporation contemplating the building of any dam or reservoir upon any river or stream in the State of New York, impounding or capable of impounding 1,000,000 cu. ft. and upwards of water, shall be required to file plans and specifications for the same in the office of the State Engineer, and no such person, persons, company or corporation shall award a contract for the building of such dam or reservoir, or shall proceed to build the same or any part thereof until such plans and specifications shall have been approved by the said Engineer.

The said plans and specifications shall consist of:

(1) A map showing the location of the said dam or reservoir, and the limits and area of the watershed tributary to the same, from actual survey.

(2) A plan and cross-section or sections showing the character and principal dimensions of said dam or reservoir, including the waste weir or spillway of the same, and the anticipated depth and character of the foundations.

(3) A copy of the specifications under which it is proposed to execute the work of construction of the said dam or reservoir.

The decision of the said Engineer upon the above plans and specifications shall be rendered within 30 days of the date of filing the same in his office.

Such a bill would not obstruct the building of small private reservoirs, and ice ponds, and would only cover cases of real danger, when 30,000 tons and upwards of water may through inadequate means of retaining them, be sent thundering down a populous valley. It would oppress no interest, be directed against none, and would be a benefit to all. It would not only protect the public, but would afford to the owners of reservoirs the advantage of an expert examination of their plans without cost to themselves.

Is not this matter worthy of consideration?

E. Sherman Gould.

Yonkers, N. Y., Sept. 26, 1902.

The Safe Limit of Fall in Driving Piles.

Sir: Your remarks upon pile driving, in connection with the letter of "Contractor," published in your issue of Sept. 25, 1902, should be a warning against the present almost universal practice, where piles are driven in hard material, or to a hard bottom.

My conclusion, derived from a large experience, is that more piles are dangerously injured by improper driving from excessive weights of hammer and undue heights of falls, than are rendered unsafe through insufficient driving. I have repeatedly observed piles, when driven in hard material under a heavy hammer and excessive fall, suddenly move several inches after the pile had practically reached refusal; this supposed extra penetration was simply the result of the breaking of the pile, and its subsequent movement under additional blows. In a case in mind ten successive piles in an important foundation, driven with a 3,000-lb. hammer, and a 30-ft. fall, behaved in the above manner, and the inspector in charge of the work accounted for the resumption of the penetration of the pile by the assumption that its point had met with and passed through a layer of soft material. The subsequent removal of these piles showed that every one had been broken near the mid-length of the pile.

In the removal of pile piers I have had frequent occasion to examine the piles after they had been withdrawn, and when driven to hard bottom the piles were generally found either broken at some point considerably above their lower ends, or else the piles had split at their points, and spread out so as to resemble inverted mushrooms several feet in diameter; in both cases the piles had been injured by excessive driving. Beyond the above injury to piles, excessive driving results in a degeneration of the fiber of the piles which reduces their strength as columns, and also materially hastens decay.

The brooming of the head, and the mushrooming of the point of piles is often misunderstood by the engineer, inspector, or contractor for penetration; and further driving, when piles have reached such a stage, is injurious to the piles, if not actually dangerous to their stability. My experience leads me to the conviction that a very great number of piles, in hard driving, are broken by the pre-

valling heavy hammers and excessive falls, without the parties in interest suspecting the fact.

It was proven by the experiments of Major J. Sanders at Fort Delaware in 1850, that two 10-ft. falls were fully as efficient as one 20-ft. fall, in establishing the final bearing power of piles. The possibility of injury to the pile by two such blows is much less than that which might result from a single blow of double the height. It therefore follows that prudence indicates the wisdom of low hammer falls, even at the sacrifice of time in driving the pile.

You have rendered a marked service to the profession by inviting attention to the subject under reference.

Yours very truly, L. Y. Schermerhorn.

310 Mariner & Merchant Bldg., Philadelphia, Pa.

Sir: Complying with your invitation in the issue of Sept. 25, I would say that I have had an extended experience in the driving of piles. As pile recorder for the New Orleans & Northeastern R. R. I had charge of four miles of the Lake Pontchartrain trestle and during the past year I have had occasion to drive about 10,000 piles near Sault Ste. Marie, Ont.

The limit of safe driving depends upon five principal factors, as follows: (1) The weight of hammer; (2) Sustaining material; (3) Species of pile; (4) Diameter and length of pile; (5) Protection given to the pile head against brooming. To these can be added, position of leads, guide friction, condition of pile timber—whether dry, green or creosoted.

It is impossible to deduce from all of these conditions a formula for determining particular constants and coefficients. In Louisiana, where the driving was in alluvial muck, a 3,000-lb. hammer slowly lowered on the pile would often sink the same 15 ft. and the hammering had to be controlled in order to not drive the pile clear of the leads.

On Lake Superior the driving is through strata of silt, gravel, sand, clay and hard pan. The piles used here were white pine, red pine, Norway pine and tamarack, and were from 40 to 60 ft. long. The weight of the hammer was 3,600 lbs. and it ran in 40 ft. leads. Great care was exercised to prevent the pile butt from brooming and instead of the ordinary way of ringing the pile, a cast-iron follow in which was inserted an 8-in. maple block protected by a rope mat intervened between the hammer and the pile.

Under these conditions a white pine pile would invariably split between a 10-ft. fall of the hammer and a clay bottom. Great care and judgment had to be exercised to drive these piles to a bearing.

Red pine, Norway pine and tamarack would stand a 15-ft. fall of the hammer provided they were 12 ins. diameter on the butt. Eight-inch. piles of these timbers would split badly and would be liable to break as soon as a hard stratum was encountered. An 8-ft. fall of the hammer had no injurious effect provided no boulder was encountered.

There is no doubt that the best method of driving piles is by the steam hammer, where a succession of quick, short blows drives the pile home. However, machines of this kind should be equipped with hammers of different weight and the hammer should be changed according to the resistance which is offered by the sustaining material. In all cases the pile head should be well protected; even slight brooming will diminish the effect of a blow. Small soft wood piles so driven with 3-ft. fall of 3,000-lb. hammer into clay showed no brooming at the point nor any breaks when pulled up.

My experience is that the driving of piles with the ordinary hoist hammer cannot be reduced to a precise science. It will always remain a matter of skill on part of the pile-driver engineer in catching the hammer just at the right moment, judgment on the part of the foreman to regulate the fall of the hammer and common sense on the part of the engineer in directing and supervising the operations and knowing when to stop. Respectfully yours,

G. W. Stadly, Engineer Maintenance of Way,
Algoma Central & Hudson Bay Ry. Co.

Sault Ste. Marie, Ont., Sept. 30, 1902.

Notes and Queries.

F. W. A., Swedenborg, Mo., desires the definition of a "pony truck" on a locomotive.

It is a two-wheeled truck and is also known as a Bissell truck.

BOOK REVIEWS.

BETON ARME ET SES APPLICATIONS.—By Paul Christophe, Ingenieur Ponts et Chaussees. Ch. Beranger, Paris. Cloth; 6¼ × 9¾ ins.; pp. 755; illustrated.

Beton arme, as most of our readers know, is the term used by French engineers to define any construction of concrete strengthened by an embedded skeleton or framework of metal, nearly always iron or steel wires, bars or beams. Concrete-steel construction is the synonymous but somewhat more cumbersome term in English. Concrete-Steel Construction and Its Application, therefore, serves very well as an idiomatic rendering into English of the title of the book which has been prepared by Mr. Christophe. Considering the comparative newness of concrete-steel construction and the many doubtful and disputed questions respecting its calculation and design, the book is an excellent treatise on the subject which it covers. It should prove useful to American engineers who have anything to do with concrete-steel construction, and there are few who do not or who are not likely to have something to do with it if there is a continuation of the favor with which it is at present received.

Beginning with a brief account of the historical development of concrete-steel construction in Europe and America, the bulk of Chapter I. is devoted to defining, classifying and describing briefly the different systems of construction which have been invented by various persons, and to the general discussion of the principles and theories upon which these constructions are based. Chapter II. describes and illustrates by actual examples the manner of applying these various systems of construction to the construction of buildings, bridges, retaining walls, foundations, conduits, reservoirs, tanks and diverse other structures. This chapter comprises some 385 pages of the book, and gives a vast amount of information, showing the numerous applications and wide use of concrete-steel construction at the present time and particularly in Continental Europe. Chapter III. summarizes the various experimental investigations which have been made on concrete-steel construction, discusses its theory and gives useful and practical formulas and the usual methods adopted in its calculations. Chapter V. discusses briefly the advantages and disadvantages of concrete-steel as a structural material. The book presents an excellent bibliography of articles and books which have appeared in various places and different languages. There is also a useful index.

THE ELECTRICAL CATECHISM, 533 Plain Answers to 533 Practical Questions About Electrical Apparatus.—Compiled from the regular issues of "Power." New York: The Hill Publishing Co. Cloth; 6 × 9 ins.; pp. 210; with 246 illustrations. Price $2.

"There is no royal road to learning," runs the old maxim, and it is as true now as it ever was. Nevertheless there are a variety of roads available to the traveler in this direction; and it must be confessed that some are much more smoothly paved than others. Among the favorite systems of those who endeavor to make the pathway to knowledge smooth enough for infant feet to tread is the catechism method of instruction, and it certainly has very much to commend it. The book before us adopts this method to impart an elementary knowledge of electricity. Naturally, only a small part of the sum of human attainment in this field can be compressed into the answers to 533 questions; yet the compilers of this book have done heroic work in this direction. We are inclined to doubt whether the student of this catechism who works without other aid and with no opportunity to see, handle or work with actual electrical apparatus, will be able to gain a saving knowledge of the subject from this book alone. But as an aid to self-instruction by employees of electric light and power stations, electric railways or manufactories of electric apparatus, it should prove extremely valuable. The engineer whose professional education was completed before the days when electricity was a part of engineering and who wishes to bring himself up to date can study this little book with much profit.

A HIGH DROP TEST OF AN ELEVATOR SAFETY AIR CUSHION.

A test of the air cushion installed at the foot of the elevator shaft in the Philadelphia City Hall tower was made on Sept. 29, in the presence of several hundred invited guests. As most of our readers are aware, the tower of the Philadelphia City Hall attains the greatest height of any building ever erected. It is 500 ft. from the pavement to the base of the statue of William Penn, which surmounts the tower. The accompanying cut, Fig. 1, gives a perspective view of the building. An elevator in the tower carries visitors from the upper floor of the building to a point just below the base of the Penn statue.

The test consisted in letting the regular passenger elevator car, weighing about 2,500 lbs., drop from the top of the shaft, a free fall of 290 ft. before entering the well-like chamber 75 ft. in depth called the air cushion. In the car were a lighted lantern, six rats, 50 incandescent light bulbs, and several dozen eggs. A New York reporter begged for the privilege of accompanying the rats, but was refused. At 1:30 P. M. the car was cut loose, and four seconds later it shot like a flash out of sight into the air cushion. Two seconds afterward there was a cannon-like report, accompanying the escape of the suddenly compressed air through the valves. The sliding steel door of the air cushion chamber was then drawn back, and inspection showed that while the lantern was upset, and a few of the eggs were broken, the rats were unscathed save for a bath of kerosene oil, and the incandescent bulbs were unbroken. The elevator car appeared to be uninjured. The test is a remarkable one in that the total fall, 365 ft., exceeded by 65 ft. any previous test. The velocity of the car upon entering the air chamber after a free fall of 290 ft., neglecting air and guide friction, was about 136 ft. a second, or nearly 93 miles an hour. A 2,500-lb. car after falling 365 ft., friction neglected, would possess 912,500 ft. lbs. energy; and if this energy were overcome by opposing a uniform resistance during the 75 ft. of fall in the air cushion, its necessary resistance would be more than 12,000 lbs. The area of the car floor was approximately $5 \times 6 = 30$ sq. ft., so that the pressure upon the floor under the conditions assumed would be 400 lbs. sq. ft., or about 3 lbs. per sq. in. The maximum pressure was, of course, much greater than this, probably more than double, for the pressure starting at zero increased as the car descended until a maximum was reached. A 150-lb. man under similar conditions of uniform retardation would experience an upward pressure of 720 lbs. upon the soles of his feet, and probably not less than double, or say 1,500 lbs. at the moment of stopping, while the pressure upon the hip joints would be about two-thirds that on the feet. A Sandow would readily sustain such a load without weakening at the hips or knees, but an ordinary man would almost surely collapse, although, of course, with injurious results by no means comparable to those that would follow a free fall of much less height. Mr. F. T. Ellithorpe, President of the Ellithorpe Safety Air Cushion Co., has himself many times dropped six stories without the least injury.

Relative to the egg as a means of testing the effect of a sudden stopping of a falling elevator car, some experiments made by a member of the staff of this journal were described in our issue of July 28, 1898. It was there shown that an egg pressed between flat surfaces was crushed by a pressure of 4½ lbs., which was 38 times the weight of the egg. Bearing also upon this point we are in receipt of the following letter from Mr. Charles L. Duenkel, M. E., formerly Chief Engineer of the Ellithorpe Safety Air Cushion Co., and designer of the air cushion in the Philadelphia City Hall tower:

Sir: I have given the subject of tests of elevator air cushions recently made in a public building in Philadelphia, Pa., my careful consideration. Guided by a considerable experience as chief engineer of a local air cushion company, I feel obliged to protest against the claims for safety alleged by the placing of eggs in an elevator cage and then permitting the cage to fall and be checked by the action of the air cushion.

The conditions imposed are in no sense correlative with that of a human being falling in the cage. The degree of pressure at which an egg will rupture is about 95 times its weight when the major length of egg is set horizontal, and about 140 times its weight when its major length is set vertical. A human being can safely receive a pressure from the conditions imposed not to exceed five times his weight.

I submit for your consideration a summary of the tests made by me in the falling of elevator cages loaded with eggs to an air cushion, each egg weighing about 2 ounces.

First. The major length of egg set horizontal the result was:

1.	Crushing force,	9.66 lbs.;	77.35	times its	weight.
2.	"	"	13.35	"	106.8	"	"	"
3.	"	"	11.49	"	91.98	"	"	"
4.	"	"	14.3	"	114.4	"	"	"
Total	"	"	48.80	"	390.53	"	"	"

Average crushing force per egg, 12.2 lbs., or 97.63 times its weight.

Second. The major length of the egg set vertical the result was:

1.	Crushing force,	16.79 lbs.;	134.35	times its	weight.
2.	"	"	14.77	"	118.2	"	"	"
3.	"	"	24.63	"	197.05	"	"	"
4.	"	"	16.20	"	129.60	"	"	"
Total	"	"	72.39	"	579.20	"	"	"

Average crushing force per egg, 18.1 lbs., or 144.8 times its weight.

I believe the data submitted will disprove the fallacious claims for safety advanced in the test referred to, and I trust induce tests of a safer character to be imposed on the installation of air cushions. Yours very truly,

Chas. L. Duenkel.

120 Liberty St., New York city, Oct. 2, 1902.

From the results of these tests it is quite evident that, provided no jar took place, an egg would stand a drop in an elevator car falling a distance of at least 38 times the depth of the air cushion, according to Engineering News tests, and 95 to 145 times the depth of the air cushion, ac-

cording to Mr. Duenkel's experiments, assuming a uniform retardation in the air cushion. In the 365-ft. fall in the Philadelphia City Hall tower where the ratio of air cushion depth to total drop is about one to five, it is manifest that the few eggs which broke were broken by jar at the time the car struck the bottom, and not by pressure developed by their inertia.

While pressure developed by inertia would not crack the eggs, it would, as we have shown, cause a man to feel as if he literally weighed a ton, and might result in serious injury.

The egg test is, therefore, very unsatisfactory, as proof of the effectiveness of the air cushion as a safety device. The fall of animals in the car without injury is much more convincing, and the larger the animal the more convincing would such a test be.

So far as one could judge by the sound there was no perceptible rebound of the car when it reached the bottom of the air cushion, the air escaping through the valves preventing a rebound.

FIG. 1. VIEW OF CITY HALL, PHILADELPHIA.

THE AIR CUSHION.

In ordinary building construction the air cushion is located in the basement, but in the Philadelphia City Hall it is suspended in the tower proper, with its base a few feet above the third story floor.

In proportioning the air cushion it has been found necessary to make its depth from 1-6 to 1-4, usually 1-5, the maximum possible drop of the elevator car. The sides of the air cushion chamber in the Philadelphia City Hall tower are of 5-16 sheet steel, stiffened with horizontal 5-in. I-beams, 19 ins. c. to c. At the bottom is a heavy sliding steel door which is of course closed after the entrance of passengers into the car. There is a clearance of about ½-in. between the elevator car and the sides of the air cushion. An air escape vent is provided in one side of the air cushion and is triangular in shape. Its base, 4 ins. wide, is located at the top of the air cushion, and its vertex is 35 ft. below. Fifteen feet below the vertex of the escape vent is an escape valve having a circular opening 15 ins. in diameter, and 10 ft. from the bottom of the air cushion is another similar escape valve. The springs of the valve, as shown in Fig. 2, are so proportioned that at a pressure of about 3 lbs. per sq. in. on the valve surface it will begin to open, and at 9 lbs. per sq. in. the valve will have reached its maximum opening. Near the bottom of the air cushion is a check-valve which permits air to flow inward and prevents the formation of a vacuum under the car when it begins its ascent.

We would suggest that the use of the triangular opening or vent near the top of the air cushion is not mechanically correct, for at the moment that the car enters the air cushion the pressure of the enclosed air is zero, and instead of providing means for the escape of the air at that moment, it should rather be confined, in order to bring the air pressure up and begin retarding the car as quickly as possible.

The valves should then be set to blow off at a pressure that will provide for uniform retardation of the car in its passage down the air cushion and at a rate which will just suffice to bring it to a full stop when it reaches the bottom of the air cushion chamber.

Four ordinary compound elevator springs are provided at the bottom of the air cushion to act as bumpers. The springs are about 5½ ins. diameter, 16 ins. high and susceptible of a 7-in. compression.

It will be evident that in case the car should fall into the air cushion from some point below the top of the shaft and the valves were the only means of escape, the car would be stopped before it reached the bottom of the air cushion or more quickly than necessary. As actually installed, however, there is a narrow air space all round the sides of the car between it and the wall of the chamber and the air escapes here as well as through the air valves in case a car falls into the cushion.

The total weight of steel in the City Hall air cushion is about 120,000 lbs., and the contract price in place was $25,000.

Similar air cushions have been in use for many years in office buildings, among which may be mentioned the 20-story Empire Building, and the World Building in New York city; the Frick Building in Pittsburg, and the Temple Court Building in Minneapolis. Government officials are said to be contemplating putting an air cushion in the elevator shaft of the Washington Monument. The height of the monument, it may be observed, is 550 ft.

A good deal has been said for and against the air cushion as a safety device. A fair conclusion seems about as follows: An air cushion should only be regarded as an emergency appliance, supplementary to a first-class equipment of automatic safety catches on the car. As such an emergency appliance it should prove a valuable adjunct in saving lives and limbs in case all other safety appliances fail and the car falls.

We are indebted to Mr. F. T. Ellithorpe, President of the Ellithorpe Safety Air Cushion Co., of New York, and to Mr. Charles L. Duenkel, M. E., former Chief Engineer of the same company, for courtesies and aid in securing material for this article.

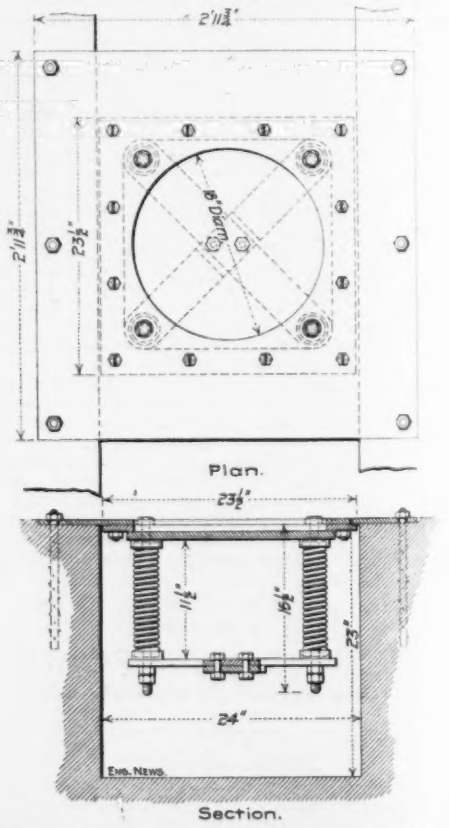


Fig. 2. Plan and Elevation of the Ellithorpe Air Valve.

THE SECOND REPORT OF THE ROYAL COMMISSION ON SEWAGE DISPOSAL.

The first report of the Royal Commission, appointed in 1898 "to inquire and report what methods of treating and disposing of sewage (including any liquid from any factory or manufacturing process), may properly be adopted," was published in 1901. It was a thin blue book, consisting mainly of preliminary conclusions, which latter were reprinted in our issue of Aug. 15, 1901. Under date of July 7, 1902, the commission has issued a collection of "reports which have been made by the officers appointed by us for the purpose of our investigations." These ten reports deal with some of the bacterial phases of sewage, particularly as regards pathogenic germs, and also with the pollution and self-purification of the River Severn.

The reports range in date from May 10, 1900, to May 23, 1902, their order in the blue book, in general, corresponding to their several dates.

Before considering these reports it may help some to a better understanding of the situation if it is stated that one of the chief causes for appointing the commission was the differences of opinion which arose between local authorities and the Local Government Board of Great Britain, which passes on all municipal loans. These differences of opinion were in relation to sufficiency of the new rapid bacterial processes of sewage treatment when not followed by the application of the effluent to land. The Local Government Board formerly insisted on land treatment, which in England generally means broad irrigation, irrespective of the methods to which the sewage had already been subjected. The conclusions of the first report may be summarized as follows:

(1) While it is doubtful "if any land is entirely useless" for treating sewage, "peat and stiff clay lands are generally unsuitable" for the purpose, their use is always difficult, and, where efficient purification is required, sometimes impracticable.

(2) Artificial processes, unaided by land treatment, will give "effluents which will not putrefy, which would be classed as good according to ordinary chemical standards, and which might be discharged into a stream without fear of creating a nuisance."

(3) The protection of rivers from pollution is in so uncertain a state, both as to methods available and the actual dangers from pollution, and at the same time the matter is so important, that "a supreme river's authority" should be created to deal with the problem, with power, on appeal, "to take action in cases where the local authorities have failed to do so."

It should be noted that in (2) the commission was careful to limit its approval of bacterial process effluents to their freedom from nuisance producing qualities, and said nothing regarding the bacteria left in such effluents; also that in (3) it expresses uncertainty regarding the dangers from discharging the effluents from sewage purification works into streams. The investigations described in the second report appear to have been designed particularly to throw light on these very subjects.

The Oxidation of Stale Sewage.

The opening report, by Mr. Colin C. Frye, a chemist, presents briefly some experiments designed to ascertain the changes taking place in sterile sewage exposed to the air in thin films, it having long been known "that sterile sewage undergoes no change when kept" under ordinary conditions. To this end sewage sterilized by various means was filtered through both sterile and non-sterile filters. The sterile filters effected an average purification of 15%, and the normal filters, 42%. The final conclusion was

> that the oxidation of sewage containing no bacteria is very slow, or, in other words, that the chemical oxidation due to the oxygen in the atmosphere is unappreciable.

Manchester Experiments on the Treatment of Sewage.

Prof. R. Boyce here reviewed the expert's report on the Manchester experiments, dated Oct. 30, 1899, and signed by Mr. Baldwin Latham, Prof. Percy F. Frankland, and Prof. W. H. Perkins.

Professor Boyce believed the length of the observations, one year, "too short a period in which to come to a definite conclusion, especially as regards the life of a bed." He also noted that the tests of effluents were chemical, only. He believed

> the septic tank will gradually sludge up and the more the tank tends to sludge the more sludge in suspension is carried over into the contact beds, owing to the disturbance of the gradually rising floor of sludge.

Inasmuch as the septic tank, in many installations, is designed to reduce to a minimum the suspended matter applied to filter beds, it is of great importance that such tanks be properly regulated with that end in view.

Although the sludge problem is not eliminated by the septic tank, yet the sludge which the tank produces was not, at Manchester, so "prone to putrefactive decomposition" as that from chemical precipitation.

A combination of the anaerobic and aerobic processes is better than the aerobic alone, as the experts stated in their report, provided, Professor Boyce adds, "the septic process is made more perfect than at present and suspended sludge be prevented from passing over on to the beds."

That sedimentation must be employed prior to treatment on contact beds. Professor Boyce agreed, but he thought

> the experience is hardly long enough to enable us to say definitely that the septic tank is the best means of bringing about the sedimentation and the destruction of the solid material of sewage.

Bacterial analyses (apparently made by the Royal Commission) showed that the effluent from the first contact bed yielded 331,700 bacteria per cu. cm., and 1,420 coli per cu. cm., while the second contact bed gave 115,100 and 329, respectively. The author did not think 300 bacillus coli passing into the Manchester ship canal would do harm (the canal above the sewage outfall contains 20 times that number), but accepting 300 as a standard, can it be maintained? The experts had stated that "no solid organic impurities must go on the beds," but "the septic tank as at present worked, is not preventing this." In fact, the bed effluents "still contain a considerable quantity of solid matter in suspension." It appears to be quite as important, Professor Boyce says in conclusion, to keep solid matter from the canal as coli communis, and, therefore, it is clear "that further observation of the septic tanks and contact beds is necessary."

Following the review just abstracted is a longer one of both the Manchester reports (Oct. 30 and Dec. 22, 1899), by Dr. S. McGowan and Mr. Colin C. Frye. Only a few points need be mentioned here. The first one is that the small size and sloping sides of the Manchester contact beds gave superficial areas 3½ times greater than that of the bottoms of the beds, and therefore more opportunity for aeration than is afforded by large beds.

The gain in capacity of contact beds after resting, Mr. Frye thought after observations at Leeds,

> is due mainly to mechanical shrinkage of the spongy matter present, and only in a lesser degree to oxidation. He bases this view on the fact that the proportion of volatile to non-volatile matter in different sludges—whether these be taken from the interior of a filter bed or from a septic tank—is much the same for a given sewage. On the other hand, the examination of filter bed gases shows that oxidation goes on actively when a bed is resting.

The amount of iron in the Manchester septic tank effluent, and also in the effluent from the first contact bed, together with suspended matter in the tank effluent, suggest that "either more tank accommodation" or else "some rough and easily renewable filter between the tank and the filter beds proper."

The Bacteriology of Crude Sewage and Sewage Effluents and Standards for Potable and Non-Potable Streams.

This report was made by Dr. A. C. Houston, and dated Feb. 26, 1901.

BACTERIA IN CRUDE SEWAGE.—Crude sewage usually contains at least 1,000,000 bacteria per cu. cm., and not uncommonly 10,000,000, while the number of bacilli coli communis or other closely allied intestinal forms, "is apt to be at least 100,000 per cu. cm." In addition, there are "usually at least 100 per cu. cm." of bacilli enteritidis sporogenes in crude sewage. The test for the latter organism is an easy one "and gives some indication of the total number of spores of anaerobic bacteria of all sorts present in the substance under examination." The coli test is performed under aerobic, and the enteritidis test under anaerobic conditions. Spores of enteritidis "are absent from as much as 100-500 cu. cm. of a pure water, are present only in sparse numbers in virgin soils, but are present in great abundance in soils polluted" with excremental matter.

Streptococci seem to be present in crude sewage to the number of at least 1,000 per cu. cm.; "are present in the intestinal discharges of animals;" and "are seemingly absent from relatively large amounts of pure waters, and from virgin soils, but can be readily demonstrated in soils and waters recently polluted with excremental matter." The test for this organism "must be regarded as an index of no mean biological quality of a sewage effluent in relation to the possible spread of disease," even though its pathogenicity, as found in sewage, "does not appear to have been established."

The author next points out the usefulness of the gas test for indicating the presence of bacteria of sewage origin; notes the fact that the subcutaneous inoculation of rodents with crude sewage "is always followed by a local reaction, and not uncommonly leads to a fatal result," but can hardly be recommended as a routine test; and classes "the enumeration of thermophilic bacteria, liquefying microbes, spores of aerobic bacteria, etc.," as secondary "to the tests already considered."

BACTERIA IN EFFLUENTS FROM ARTIFICIAL PROCESSES.—The small amount of information on the bacterial contents of effluents from the newer and rapid processes of sewage treatment makes the information given in the report under this head of particular interest. The opening paragraph of this section of the report is as follows:

> The effluents from septic tanks, intermittent contact beds, continuous filtration beds, etc., contain an enormous number of bacteria. In some cases the percentage reduction of microbes in effluent as compared with raw sewage is striking. But as an effluent must be judged from the actual state it is in, and as the number of micro-organisms still remaining is nearly always large, percentage purification would seem to be of minor importance. In not a few cases the bacteria are practically as numerous in the effluent as in the raw sewage.

The bacterial contents of crude sewage and effluents, both in number and kind, "appear to be very much the same;" the reduction of objectionable organisms, like the bacillus coli communis, proteus-like germs, enteritidis sporogenes and streptococci, "in no case, seemingly," having been "so marked as to be very material from the point of view of the epidemologist." For these and other reasons the conclusion is reached that "effluents from bacteria beds are bacteriologically so impure that they may well be excluded from streams that are used for drinking purposes," which is "the more to be regretted since the same effluents often pass a reasonable chemical standard."

BACTERIA IN EFFLUENTS FROM LAND TREATMENT.—While possible by this means to obtain good bacterial results, and even, though rarely, effluents which in themselves "might actually be regarded as potable water of more than average purity," yet generally land treatment effluents "are not to be thought of as in a fit state to be turned into a potable stream." The chemical and bacterial results from land treatment, however, are more nearly equal, in degree, than those from bacteria beds, a point in favor of the former, but still the land effluents contain coli, enteritidis, sporogenes and streptococci.

BACTERIA IN EFFLUENTS FROM CHEMICAL TREATMENT.—The author thinks it a serious question whether sufficient evidence exists to enable one to pass judgment under this head, although he does "gather" that the process "in general does not destroy the sewage bacteria."

STANDARDS FOR EFFLUENTS TO BE DISCHARGED INTO DRINKING WATER STREAMS.—While chemical analyses, alone, are insufficient under this head, yet it should be noted that they are required to show that effluents, even though sterile, contain "no organic substance susceptible to the action of putrefactive bacteria present in the water of the river;" and also, where drinking water is concerned, to show that the effluent "is free from chemical poisons in dangerous amount."

The author recognizes the fact that the bacteriologist has not yet an "infallible test enabling him to say—this effluent does not contain the specific germs of disease," but he has "the microbes of indication" to guide him. The available means of rendering effluents partially sterile (that is, free from all organisms but spores), and completely sterile are discussed. Complete sterilization of effluents is at least impracticable. As to partial sterilization the author says:

> It seems justifiable to conclude that the destruction of B. Coli would mean the death of the typhoid bacillus, and perhaps in general of the germs of epidemic disease. And it may be seriously questioned if the practical difficulties and the cost of such partial sterilization is in any way out of proportion to the enormous gain in securing comparative immunity from danger. A large number of substances would seem to be capable of effecting this object at reasonable cost, *e. g.*, ozone and chlorine compounds.

Further experiments are suggested to determine

the best means and the cost of sterilizing and partially sterilizing sewage effluents.

As a tentative standard for effluents discharged into potable waters the author suggests that they be

free, or nearly so, from putrescible matter as judged by chemical standards; and be free also from the specific germs of epidemic disease, *e. g.*, B. typhosus as judged indirectly but seemingly in safe fashion by the absence of B. Coli. It might be convenient to fix some limit, *e. g.*, that B. Coli must be absent from 1 cu. cm. of a sewage effluent, that if this end could be attained by filtration or other method not to consider the use of chemical substances essential. Nevertheless, even sand filtration could not render an effluent innocuous in the same way as sterilization. Such a standard as that suggested has the advantage of extreme simplicity, and it would take no note of the relative volumes of the effluent and river water, a matter which, if taken into consideration, greatly complicates the question of standards.

STANDARDS FOR EFFLUENTS DISCHARGED INTO NON-DRINKING WATER STREAMS.—The author first discusses the possible dangers from occasional use of such streams for drinking, from the more or less frequent use for washing milk cans and for bathing, from admission of river water to wells through infiltration or through flooding, and from ordinary fish and shell fish. Such dangers tend "to affect individuals rather than large communities," so the author is

inclined to say that in the case of non-drinking streams—*except where oysters and other shell fish which are eaten raw are concerned*—the bacteriological character of an effluent is of secondary importance. But even from this secondary point of view the bacteriological examination may be of considerable utility for ascertaining the actual or potential putrescibility of an effluent.

FINAL SUMMARY.—The conclusions of Dr. Houston's report are as follows:

(1) That both bacteria bed processes and land processes can yield effluents seemingly non-putrescible.
(2) That in general the effluents from bacteria beds and from land are not to be thought of as safe in the case of drinking streams.
(3) That chemical standards are essential in the case of potable and non-potable rivers.
(4) That a bacteriological standard is most certainly indicated in the case of drinking streams, and is of more importance than the chemical one.
(5) That a bacteriological standard is of secondary importance in the case of non-drinking streams, but may prove useful as an adjunct to the chemical standard.

A Study of Anthrax Bacilli in Yeovil Sewage.

This report, also by Dr. Houston, is in a measure supplementary to the preceding one. The study was begun in March, 1901, and the report is dated December, 1901. The sewage of Yeovil "has the reputation of being excessively foul," due to the large amount of trade waste which it contains, the worst of which comes from "twelve or more hide factories."

An experimental septic tank and double contact beds of coke were installed some years ago at Yeovil, and after about four years of use were abandoned. Septic tanks, artificial filters and final dispqsal on land have been adopted for the treatment of sewage and storm water from the whole sewage system. Dr. Houston's experiments consisted of tests for anthrax in the stagnant liquid and in the sludge remaining in the experimental septic tank, and in the washings from coke dug from both of the experimental coke beds, all of which had been out of use a number of months (from November, 1900, to March or April, 1901). The tests also covered examinations for anthrax in the effluent from a "final catchpit in a hide factory," and mud from the banks of the River Yeo and the Yeo Brook, both of which streams receive sewage. Anthrax were found in the septic tank liquor and sludge of the septic tank, and in the washings from both coke beds. This proved that the organisms passed the septic tank and the first coke bed, but as the beds were not in operation, it could not be shown whether anthrax passed the second bed. Samples of crude sewage and brook water showed no anthrax, but positive results were given in the case of mud from the beds of each stream, and also in the case of the catchpit sample from the hide factory. The tests are held to indicate the possibility of contamination of water, and of grazing lands subject to flooding, wherever either crude sewage or sewage effluents from septic tanks and double contact beds are discharged into streams, provided, of course, that hide factory wastes are involved. No practicable plan for sterilizing the hides or the wastes from their treatment could be suggested at the time of the report, but further information was promised.

The Subcutaneous Inoculation of Animals with Crude Sewage and other Effluents.

This is still another report by Dr. Houston, whose studies for the London County Council on the bacteriology of sewage were described in our issues of Nov. 9, 1899, and Jan. 24, 1901.

The studies in this report included the inoculation of guinea pigs with crude and settled sewage from several places, with street washings, with effluents from sewage farms at Rugby, Leicester, Nottingham, and elsewhere, also with effluents from the Exeter septic tank, and from Dibdin and Ducat contact beds.

Dr. Houston summarizes the results of this investigation as follows:

(1) The subcutaneous injection of crude sewage into guinea pigs (about 1 to 3 cu. cm. per 200 grammes body weight) always produces a local reaction and not uncommonly death within 24 to 72 hours.
(2) "Street washings," storm-water overflow, liquid from sewage works, and in general bad effluents, are also apt to be pathogenic under the above conditions of experiment.
(3) Good effluents may be injected in relatively large amount without producing a fatal result.
(4) Land effluents, in my experience, are usually less pathogenic than effluents from bacteria-bed processes of sewage disposal.
(5) If sewage or effluents be previously heated to 80° C. for 10 minutes a pathogenic result may still be produced, but usually a much larger dose of the liquid is required.
(6) If sewage or effluents be previously heated to 100° C. for one hour large doses of the liquid fail to produce a pathogenic effect.
(7) Sewage rendered germ-free by filtration through a sterilized Pasteur filter may be injected into guinea pigs in large amount without producing any appreciable result. Preliminary heating of the sewage to (a) 65° C. for 20 minutes, (b) 80° C. for 10 minutes, (c) 100° C. for one hour does not seem to affect this negative result.
(8) Some samples of sewage and effluent contain B. pseudo-tuberculosis and some B. pyocyaneus. Both these microbes are highly pathogenic to lower animals, and are also related to morbid processes occurring in the human subject.

In commenting on the foregoing summary, Dr. Houston first says that the results obtained with the lower animals should not be applied too closely to human beings, but he thinks that, as regards man, certain inferences may be made, some of which we condense as follows:

(1) . . . . The improbability of sewage being so modified in its biological characters by treatment on land or by artificial processes as to be other than a liquid relatively still potentially dangerous to human beings.
(2) The absence of any pathogenic result when sewage (heated or unheated) is rendered germ-free by adequate filtration is to some extent reassuring as tending to show that the chemical products of the vital activity of the bacteria in sewage are not of a markedly poison nature . . . . . in the case of rodents.

Finally, Dr. Houston calls attention to the artificial character of the experiments, and the fact that he dealt directly with sewage and effluents, instead of liquids "diluted and altered" by river water, and subjected to "other conditions of a sort likely to restrain or destroy their pathogenic qualities." These conditions may reasonably he considered, he thinks, "as arguments against accepting without qualification even the cautious inferences that I have tentatively advanced."

The Longevity of the Bacillus Typhosus in Sewage and Sewage Effluents.

The report on this subject, by Alfred MacConkey, covered tests of crude sewage, and effluents from a sewage tank, Dibdin filter bed and Cameron filter bed, some of the samples being partially sterilized and others in their normal condition. The general conclusions from the tests were as follows:

As a final conclusion it may be stated that the fluids experimented with are inimical to the growth of the bacillus typhosus, and if these pathogenic bacilli find their way into a bacteriological system of treatment they meet with conditions hostile to their multiplication.

We know that typhoid bacilli must find their way into the sewage from the excreta of persons suffering from typhoid, but they cannot be in large numbers, and in the various samples of crude sewage which we have examined we have not found any. Therefore, it may be concluded that allowing that these bacilli do reach biological beds or septic tanks, they are present in such small numbers, and the conditions are so adverse to their existence, that they will not survive the treatment. But if from any cause they arrived to the beds or tanks in such large numbers as the B. coli, then certainly they might appear in the effluent just as the B. coli does. But, as in the case of the latter bacillus, so also in the case of the B. typhosus, there is no tendency to multiplication in the effluent.

Effect of Filtration in Reducing the Number of Bacteria the Effluent from a Dibdin Contact Bed.

Prof. R. Boyce and Drs. MacConkey, Grünbaum and Hill, were associated in these studies, the report on which was submitted by Professor Boyce in November, 1901. The experiments, however, extended from Nov. 8, 1899, to April 6, 1900. The experimental filters were formed in 9-in. drain pipes, 4 ft. deep, with outlets as near the bottom as possible. Filters 1, 2 and 4 were filled with sand, and Filter 3 with light soil from the West Derby sewage farm. Each filter had 3 in. of graded gravel at its bottom. The sand in filters 1 and 4 was washed, but the material of Nos. 2 and 3 was not washed.

The liquid treated was the effluent from a Dibdin contact bed located at the West Derby sewage farm. The rate of filtration was 2,280,000 U. S. gallons per acre per day at first, 470,000 gallons later, and finally, 189,000 gallons. "At these rates the effluent dripped on to the filters, and the filtrate comes away at about the same rate." This portion of the experiments extended from Nov. 8, 1899, to Jan. 27, 1900, but analyses are reported for only some 40 days, which were not consecutive for any one filter, nor for the applied liquid. On 26 days the total number of bacteria in the applied liquid ranged from 4,327,000 to 3,870 per cu. cm., the average being 837,842. For the same days, B. coli communis ranged from 22,500 to 0, averaging 9,812 cu. cm. B. enteritidis was present 7 times out of 25 in 0.01 cu. cm. of the applied liquid, and 16 times in 0.1 cu. cm. The applied liquid, when taken in large quantities, "was turbid and occasionally underwent decomposition on standing." The results shown by the four filters are summarized as follows:

	Experimental filter. No. 1.	No. 2.	No. 3.	No. 4.	Applied liquid.
No. of determinations	23	24	21	27	26
Average number:					
Bacteria.....	79,780	50,762	31,665	113,790	837,842
B. coli	125	590	49	432	9,812
B. enteritidis present*	2:23	8:25	11:24	5:20	16:25

*Number times present compared with number of determinations for same.

The rate of flow, Professor Boyce states, was regulated with difficulty, owing to "blocking of pipes and variations of pressure," but he thinks "it may be fairly concluded that marked diminution of the number of bacteria occurred when the rate of flow was decreased." Special experiments with color bacteria and with the B typhosus and B anthrax, showed that very few of the color bacteria, and those only after a long period, and neither B. typhosus or anthrax, appeared in the filtrate. The general conclusions given by Professor Boyce are as follows:

When an effluent containing upon an average 800,000 bacteria per cu. cm. and 10,000 B. coli per cu. cm. is passed through a depth of 4 ft. of soil at a slow rate (viz., between 470,000 and 189,000 U. S. gallons per acre per day), there is a very great reduction in the total numbers and in the B. coli, and the chance of a very pathogenic bacterium like the B. typhosus appearing in the filtrate must be exceedingly small.

When it is remembered that normally the B. typhosus is not present in the excreta of all cases of typhoid, whilst the B. coli is always present in the fæces, and that the proportion of typhoid cases to the total number of the population is not large, that typhoid excreta are usually disinfected, and that it has not been shown that favorable conditions exist in sewage for the multiplication of the typhoid bacillus, it appears evident that land or other method of efficient filtration must totally remove this organism from a Dibdin effluent did it happen to be present.

In the preceding experiments the B. typhosus was mixed with the effluent flowing on to the filters in far larger proportion than would ever occur in nature, and yet it could not be found in the filtrate.

OTHER REPORTS.

Of the three remaining reports, one on "Some of the Chief Methods Used in the Bacteriological Examination of Sewage and Effluents," by Dr. Houston, need only be mentioned here, and commended to bacteriologists. The other two, on "The Pollution of the River Severn, in the Shrewsbury District," by Prof. R. Boyce and Drs. MacConkey, Grünbaum and Hill, and on "The Self-Purification of the River Severn," by Mr. Colin C. Frye, have been reserved for separate treatment in a subsequent article.

THE FOOTBRIDGE FOR BUILDING THE CABLES OF THE NEW EAST RIVER BRIDGE.*

By Isaac Harby,† Jun. Am. Soc. C. E.

The erection of one suspension bridge from which to build the cables of another has introduced new ideas and instituted a new procedure in the methods of constructing bridges of this type. The cables of the New East River Bridge No. 2, also designated as "The Williamsburg Bridge," are novel in other respects. They are the largest suspension bridge cables ever attempted, and are suspended from towers taller than those in use in any other

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bridge. These towers are also distinguished by being the first large ones of steel to be used for this purpose. It is not unnatural, then, that new methods should characterize the work of building such cables.

The engineer in charge of the contract for constructing these cables, Wilhelm Hildenbrand, M. Am. Soc. C. E., whose assistant the writer is, has invented a method of doing better work of this class in a shorter time than has previously been accomplished on any other similar undertaking.

Before entering into the main subject of this paper, a more comprehensive idea of the situation may be given by a brief description of the main cables themselves, the erection of which was the reason for the existence of the footbridge. The writer will also state briefly the conditions encountered at the beginning of the undertaking.

There are to be four main cables, each composed of 37 strands of 208, No. 6, steel wires, laid straight, all of which are finally to be squeezed into one cylindrical cable measuring about 19 ins. in diameter. The distance between the centers of the towers is 1,600 ft. The cables are to be passed over the tops of these, where each one is to rest on a saddle mounted on rollers permitting a motion of 3 ft. in the direction of the cable.

The weight of the main span of the bridge is to be carried directly by the cables, but the parts of the bridge between the towers and the anchorages are to be otherwise supported. Thus the back stays, or shore spans of the cables will have no load suspended from them. In order to equalize the tensions in the shore spans and the main span of the cables during their construction the saddles are moved back on their roller beds 3 ft. toward the anchorages and held there. This position has been determined by calculation as the proper one to balance the forces caused by the tension in the unloaded cable. The saddles will move forward gradually during the erection of the superstructure of the main span.

The elevation of the center of the cable where it will rest in the saddle is to be 332.708 ft. above mean high water, and the elevation at its lowest point in the main span is to be 161.027 ft. The cables will be anchored 617 ft. (measured horizontally) from the center of each tower, at an elevation of 76.627 ft. The end of each strand will be looped around a cast-steel shoe, held by a pin passed through the end of a chain of eye-bars built in a masonry anchorage.

During the spinning of the wires it will be necessary to support each strand on sheaves a little above the position it will finally occupy in the saddle, and also to hold each end of the strand a little back of its final position in the anchorage. The combined result of this condition will cause the center of the main span of each strand to hang about 14 ft. higher while it is being made than it will after it is lowered into its final position.

REASONS FOR CONSTRUCTING A FOOTBRIDGE.—On previous work of this kind a so-called footbridge was used, but it consisted merely of a single path from anchorage to anchorage, used only as a means of passage, and not intended as a working platform. In the case of the New York and Brooklyn Bridge, this footwalk was suspended on two 2⅝-in. wire ropes. When the Cincinnati and Covington Bridge (the second largest suspension bridge now in use) was recently rebuilt by Mr. Hildebrand, by the addition of extra cables above the old ones, the footbridge there in use was laid on top of one of the old cables.

The wrapping of the strands and of the finished cable has previously been done from travelers suspended from the cable itself. The regulation or adjustment of the wires has been accomplished by the assistance of cradles, suspended at several points along the line, from which men could reach the wires during regulation.

These methods left much room for improvement, and it became quite evident that if some sort of a working platform could be devised extending the full length of the cables to be built, and from which the cables could be reached at all points and at all times, a much better cable could be built in a much shorter time.

Thus the demand for such a working platform called into active service the inventive mind of the engineer in charge of the execution of the contract, and he has designed an original as well as an ingenious method of building large cables.

DESCRIPTION OF THE FOOTBRIDGE.—This footbridge is more than an ordinary footwalk from tower to tower. In the main or river span it is a double-deck bridge, and consists of eight continuous footways, four above and four below. The four upper footwalks are about 4 ft. below the line which will be occupied by the strands of the main cable during the time of spinning. The four lower walks are just below the line to be occupied by the cable when the strands have been placed in their permanent position. These different footwalks are connected by cross-bridges at numerous points, so that an easy communication is afforded from all parts of the structure. The two land spans are placed directly below the line of the cables, and have only a single deck of four walks.

The whole structure is supported by 16 wire ropes assembled into four groups of three ropes each, with a single rope suspended above each group. These ropes are stretched from anchorage to anchorage, and passed over the tops of the towers in saddles especially provided for them. The three ropes composing a cable are clamped together with iron bands every 5 ft., so as to keep the three together throughout their entire length. These ropes are 2¼ ins. in diameter, and are made of seven strands of galvanized steel wires, twisted together. The ultimate strength of each is 208 tons, and the weight 9 lbs. per ft. Each rope was made long enough to extend the entire distance from anchorage to anchorage, about 3,020 ft.

The ends of these cables were made fast to a 30-in. box-girder spanning an opening in the face of an inner wall of the anchorage, the girder being set at such an inclination that the end of each wire rope could pass through it parallel to its web. The ropes thus passed through are secured by means of button sockets which bear against the back of the girder.

In order to permit of some adjustment in the lengths of the different ropes forming the cables, and also for convenience in erecting, each is pieced, about 100 ft. from each end, and reunited by means of sockets with screw rods passing through them. These rods are 3⅛ ins. in diameter, 6½ ft. long, and are threaded at each end. They permit of an adjustment of 4 ft.

The ends of the four ropes are spaced along the anchorage girder about 1 ft. apart, and the ropes converge to a point on the front wall of the anchorage where they pass over a cast-iron saddle. Between this saddle and the saddle on the main tower they are clamped into one cable, and form the support for the land span of the footbridge.

The clamps are spaced every 5 ft., measured horizontally, and from each hangs a suspender rod of ¾-in. round iron and an inclined 1-in. suspender reaching sideways. Between each pair of cables is a ⅝-in. tie-rod. The lower ends of the suspenders pass through 3 × 8-in. yellow pine beams, upon which the 2 × 6-in. flooring is laid. As the slope of the land span becomes steeper as the towers are approached, it was found necessary to break the grade with a step at each beam for about two-thirds of the distance, and the rise of these steps increases with the elevation. Spruce posts bolted to each beam support a ⅝-in. galvanized wire rope handrail stretched tight. Frame towers at the middle of the land span carry sheaves for supporting a traveling rope at that point.

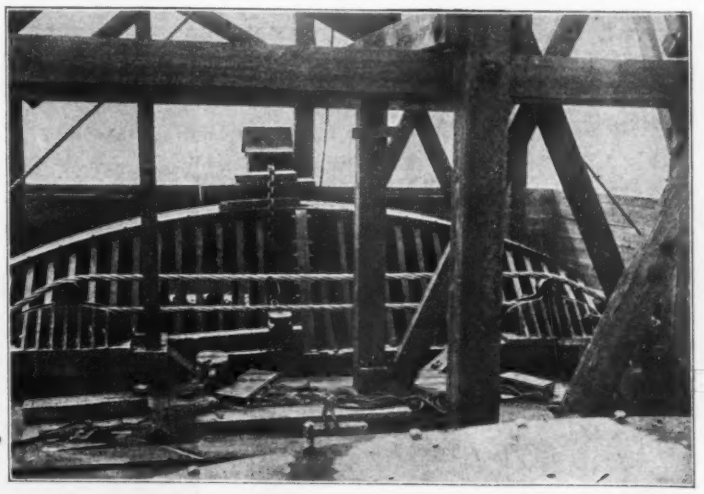


FIG. 1. VIEW SHOWING SADDLES FOR MAIN CABLE, WITH FOOTBRIDGE CABLE SADDLES ALONGSIDE.

The main span, 1,600 ft. in length, is supported for a distance of 400 ft. out from each tower by means of 1-in. suspender rods; and the remaining 800 ft., at the center of the span, rests directly on top of the cables, and is clamped to them by means of U-bolts passing between two 3 × 8-in. yellow pine floor beams bolted together. The suspender rods are hung to the clamps which bind the three ropes together. The lower ends of the suspenders are passed between the two floors beams at each point. The suspenders decrease in length as the distance from the tower increases, until they are discontinued, about 400 ft. out, where the beams rest directly on top of the cables, and are secured with U-bolts. Planking, 2 × 6-in., with 2-in. spaces between, laid across the floor beams, forms a footwalk. Cleats nailed crossways add to the security of the foothold.

The upper deck of the main span is supported on posts which rest directly upon the beams of the lower deck. These posts are capped with stringers which in turn carry beams to which is nailed the flooring similar to that on the lower deck. Handrails of ⅝-in. galvanized wire ropes are stretched on both sides of each walk.

The bridge is stiffened laterally by a cross-bracing of ⅝-in. rods. Four 2¼-in. storm cables are suspended below the main span in the form of parabolas, the vertices of which are about 4 ft. below the vertices of the four footbridge cables. The storm cables cross each other between the center and the point where they are secured to the columns of the main tower about 50 ft. above high-water mark. The land spans are held by guys attached to the steel work of the truss forming the end spans of the main bridge.

CALCULATIONS NECESSARY FOR DESIGN AND ERECTION.—In considering the design of the footbridge, the following conditions and requirements were known:

(1) Length of center span, i. e., horizontal distance between towers;

(2) Length of land spans, i. e., horizontal distance between towers and anchorages;

(3) The exact position of the main cables when finished, and the exact position of each strand while being spun;

(4) The lower deck of the footbridge, when finished, must be about 4 ft. below the line of the main cable;

(5) The upper deck of the finished footbridge must be about 4 ft. below the line of a strand being spun;

(6) The floors of the two land spans when finished must be about 4 ft. below the line of the cable when in position;

(7) Each cable must be accessible from the footbridge at every point along its length.

The general design of the structure being decided upon, the preliminary step in the calculations was the location of the saddles on the towers and anchorages in order to determine the exact span and deflection of the curves. The cable passes over two saddles on each tower, placed 6 ft. 8 ins. on each side of the center of the tower. Therefore: Length of main span = 1,600 − 2 × distance from center of tower to tangent of curve on saddle. The position of the tangent point was found approximately by scaling the drawing of the saddle after the line of the cable was laid off on it approximately at the correct angle.

The span being thus determined, the versed sine of the curve had to be found. The elevation of the tangent point of the saddle was known. The elevation of the center of the main cable at the middle of the span was also known. The distance below the center of the main cable to the bottom of the footbridge cable = 4 ft. + the thickness of the flooring, floor beams and footbridge cables. The versed sine of the loaded footbridge cable was thus determined.

The curve of this cable, after the footbridge had been built upon it, would approximate a parabola, and it had been found by experience that the formula of the parabola might be used here with practically correct results.

The load upon the bridge, while not exactly uniform per horizontal foot, is nearly so. The load due to the weight of the cables themselves is greater near the towers where the slope is steeper, but this is partially balanced by the additional weight of the timber work at the center of the span due to the increased distance between the upper and lower decks at that point.

The total load on the main span is made up as follows:

Timber work	718,000 lbs.
Rods, bolts, clamps, etc.	87,800 "
Cables	222,000 "
Storm cables	55,500 "
Guys and storm cable suspenders	19,500 "
Traveling rope	7,200 "
Total	1,110,000 "

$$\text{The load per foot} = \frac{\text{Total Load}}{\text{Span}},$$ and the equation of the curve could thus be determined.

Next, it became necessary to find the equation of the curve of the main cable hanging unloaded. This cable, being of uniform section throughout its length, will hang in the curve of the catenary, the formula for which may be determined from the given position in which the cable is required to be suspended.

By computing an ordinate of the main cable and an ordinate of the footbridge cable at the same point, the position of the footbridge floor in reference to the footbridge cable was determined, and the operation was repeated at as many points as desirable. These ordinates were computed for every 50 ft., and the curve plotted on a scale of ⅛-in. = 1 ft. After the two curves were laid out, the line of the floor of the lower deck was drawn, it being a constant vertical distance below the main cable.

After plotting these curves it was found that the line of the lower deck floor of the footbridge nearly coincided with the curve of the footbridge cable for a distance of 400 ft. on each side of the center of the span. The beams of the lower deck floor, therefore, were attached directly to the footbridge cables for that distance. The lengths of the suspenders for the remaining 400 ft. to each tower

were computed from the known ordinates at every 50 ft., and the intermediate ones were found by interpolation.

The next step was to locate the position of the upper deck. The floor of the upper deck had to be a constant distance below the strand while it was being made, this position of the strand being due to its temporary support in a position somewhat higher than that which it will occupy ultimately. Supporting the strand on sheaves over the saddles and holding the end of it back of its final position in the anchorage causes this condition.

This temporary suspension of the strand will allow it to assume the form of the catenary, the formula for which can be found, and the curve plotted on the same sheet with the upper curves. The position of the upper deck floor may then be plotted also. Comparing the ordinates of the curve of the upper deck floor with those of the lower deck floor, the lengths of the posts supporting the upper deck may be determined.

On the land spans the difference in elevation between the cable in position and the strand being made was so small that a double deck was not necessary, as the strand in either position would be easily accessible from the same footwalk. The lengths of the suspenders in this span were readily computed by a comparison of the ordinates of the footbridge cable and the main cable in position.

Having settled upon the exact position and design of the finished footbridge, it became necessary to know in what position to suspend the unloaded cables, so that they might hang at the desired elevation after the weight of the structure had been placed upon them.

To arrive at this knowledge an inverse process of reasoning was necessary. It was assumed that the bridge was standing complete, with its cables in a known position and under a known tension. The length of the cable, under these known conditions, was computed from the equation of the parabola. Then it was assumed that all the load had been removed. The cables then would hang in the curve of the catenary. The average tension was then computed from the equation of that curve. The modulus of elasticity of the rope having been previously determined by tests, the difference in length of the cable for this known difference in tension was then found. The new length being determined, and the curve known to be a catenary, its versed sine was readily computed. The elevation of the points of support being known, the elevation of the vertex of the curve was found.

To suspend the cable at the correct elevation a leveling instrument was set up in one of the towers at exactly the elevation at which the lowest point of the cable should hang.

For the adjustment of the cables in the two land spans a similar process of reasoning was used to find the curve in which the unloaded cables would hang; but, as the vertex of the curve lies outside of the points of support of the catenary, the method of adjusting the cable by means of the level could not be used. In this case the transit had to be used. It was set up at a known point between the two supports and in such a position that a line of sight could be taken tangent to the curve of the cable.

The equation of the tangent which passes through the point at which the instrument was to be stationed was found by previous calculation. The inclination of this line being known, the transit was set up and the telescope inclined at the correct angle of the tangent. In adjusting the cable it was only necessary to hang it so that its underside was tangent to the line of sight of the transit.

These calculations were all based upon a mean temperature. However, as the temperature plays an important part in the position of a cable of such length, it became necessary to make due allowance for such changes. The given position of the main cable unloaded formed the basis for all calculations as to the position of the footbridge. This position is given for a mean temperature of 60° F. The first figures obtained for adjusting the cables of the footbridge had to be tabulated for a temperature of 60° F.

The elevation for which to adjust the cable in the main span for this temperature had already been determined. If it is assumed that the temperature on the day the cable was to be adjusted would be 1° higher, the increase in temperature would cause an increase in length, but the increase in length would also cause a decrease in tension. This decrease in tension had to be taken into account in determining the amount of stretch due to tension. The true length was thus found for the new temperature, and the deflection computed and tabulated. This was done for all temperatures which were likely to occur during the time of making the adjustment. In the case of the land spans a different tangent was found for the various temperatures, and its angle tabulated to be used as required.

ERECTION OF THE CABLES.—The footbridge cable ropes were shipped by rail from Trenton, N. J., where they were made in the shops of John A. Roebling's Sons Co. They were transferred to the foot of the Manhattan tower on the deck of the largest tug of the Merritt-Chapman Wrecking Co. Each rope was 2¼ ins. in diameter, and about 3,030 ft. long. It came on a reel 7 ft. in diameter and 4 ft. wide, the whole weighing about 14 tons. A float, 180 ft. long and 25 ft. wide, previously used for the transfer of freight cars, was moored at the foot of the Manhattan tower. Three reels at a time were placed upon this float, mounted on stands bolted to the deck and placed so that the ropes could be reeled off over the side. Each reel was provided with a cast-iron brake rim over one flange of the drum, around which was passed two turns of 1½-in. manila line, one end being secured to the deck and the other held by hand.

The end of each rope was unfastened from the reel, raised over the tower, drawn back to the anchorage and secured there. This was accomplished in the following manner. The fall line from a derrick on top of the tower, operated by a hoisting engine on the float, was attached to the rope by means of a clamp about 60 ft. from its end. The end of the rope was then hoisted to the top of the tower. As the rope unwound from the reel, the loose part passed over the saddles and was placed in temporary rollers mounted on them. Fig. 1 shows the saddles for the main cable and for the footbridge cables, one footbridge rope, being in position and the other in the rollers ready to be pulled over. Another clamp was now attached about 10 ft. from the end of the rope, to which was connected a long line running back to the anchorage and operated by means of another hoisting engine located on the end-span truss about half way between the anchorage and the tower. After the tension had been taken on this "runner" the fall line on the derrick was relieved of its load and the clamp loosened on the rope so that it would slide down easily on the rope to the bottom of the tower. There it was once more clamped to the rope, and both engines were operated, one lifting it and the other pulling the end back to the anchorage. It was necessary to readjust the lifting clamp each time it reached the top of the tower, until the end of the rope had arrived at the anchorage.

The socket was next put on and the connection made to the short piece of rope previously secured to the anchorage girder. This operation was repeated until all three ropes forming a cable were similarly placed. Each in turn was removed from the rollers on top of the saddles and lowered into place in the saddle.

The next operation was to get these ropes across the river. This was accomplished with the assistance of three powerful tugboats, which towed the float across the river at slack tide. This time was selected because the current could be more easily controlled and because at this time vessels could be more easily handled and kept out of the way. The float was towed sideways, with a tug at each end and one ahead to pull. The course was kept as nearly as possible in a straight line between the two towers, and, as it was traversed, the reels were allowed to pay off the rope, which sank and lay upon the bed of the river, the ropes having been previously lashed to the bottom of the Manhattan tower.

The trip across the river occupied about 14 minutes, during which time great care had to be exercised that the reels did not pay off too rapidly. When the Brooklyn shore was reached, the float was moored to the tower. It was then found that about 400 ft. of rope remained on each reel. This was unreeled, one reel at a time, and laid along the full length of the deck of the float. About 60 ft. from the end of the rope a clamp was secured to which the fall line from a derrick on the tower was attached. The engine on the float operated the line and hoisted the end of the rope to the top of the tower. The loose end was next passed over the tower and placed on the rollers on top of the footbridge saddles. Another clamp was placed near the end of the rope, to which was attached one end of a three-part, ⅝-in. wire rope tackle, which reached to the Brooklyn anchorage, and was operated by a 60-HP. hoisting engine there. The clamp was removed from the river side of the rope as it lay over the saddles. The lashings which held it near to the foot of the Manhattan tower were cut, and everything was then in readiness to raise the rope from the bed of the river, and stretch it from tower to tower. Two government patrol boats guarded the river to prevent passing craft from interfering with the operation, which was performed at slack tide.

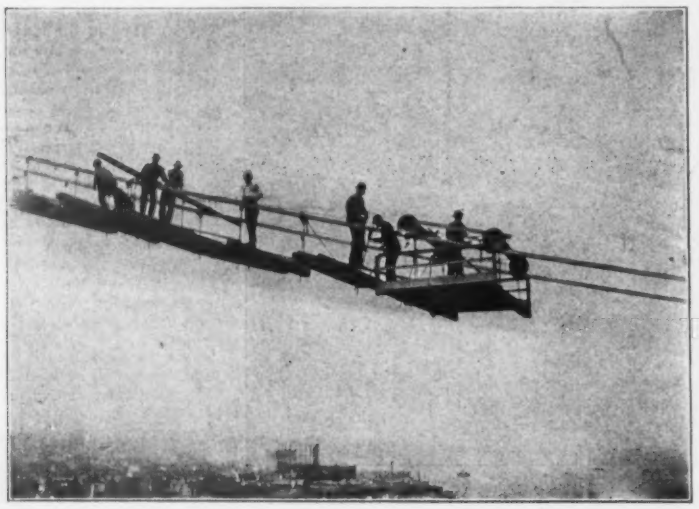


FIG. 2. VIEW OF TRAVELER USED IN ATTACHING FLOOR SUSPENDERS TO FOOT-BRIDGE CABLE.

FIG. 3. BACKWARD VIEW FROM TRAVELER, SHOWING COMPLETED FOOT-BRIDGE FLOOR ON MAIN SPAN.

At a signal from a steam whistle on the float (the signal also serving as a warning to passing boats), the engine on the Brooklyn anchorage began to pull the rope over the tower, and gradually drew it from the river bed until it had been raised nearly to its correct position. This operation consumed from 4 to 6 minutes. By this time the upper block of the tackle had traveled to the Brooklyn anchorage. The main span was now so nearly balanced with the Manhattan land span that workmen on top of the Manhattan tower, were able, by means of a set of hand tackle, to pull the rope over the tower until it was correctly adjusted.

A man with a transit stationed at the correct point below the curve fixed the position of the rope according to the temperature. Once adjusted, the men on the tower marked the rope in its correct position, and secured it against future movement.

At the same time an additional clamp was being placed on the end of the rope which had been pulled down to the Brooklyn anchorage. This was placed a little above the other clamp, and, attached to the former, was a nine-part manila tackle with its other end secured to the short rope fastened to the anchorage girder. A tension was now taken on the manila line by the engine, and the tension on the wire-rope tackle relaxed and the clamp removed. In the meantime the rope was lowered into the saddle on the Brooklyn tower, and everything was made ready for the final pull.

A man with a level stationed in the Brooklyn tower at the correct elevation according to the temperature, gave the signals to raise or lower the rope until it hung at the correct height over the middle of the river. When this was adjusted, the position of the rope was marked on the Brooklyn tower, and secured against future disturbance.

The next step was to adjust the Brooklyn land span.

This was done, as on the Manhattan side, by means of a transit set at the correct angle. The rope was lowered or raised to the correct position, which was marked on the saddle at the face of the anchorage as soon as adjusted. The rope was then measured and cut off, the socket put on and connected to the short rope fastened to the anchorage girder.

This completed the stretching of one of the footbridge cable ropes. The operation was repeated until 12 ropes, assembled into four cables, were similarly suspended. The adjustment of the subsequent ropes was made by comparison with those previously adjusted, but all were finally checked independently.

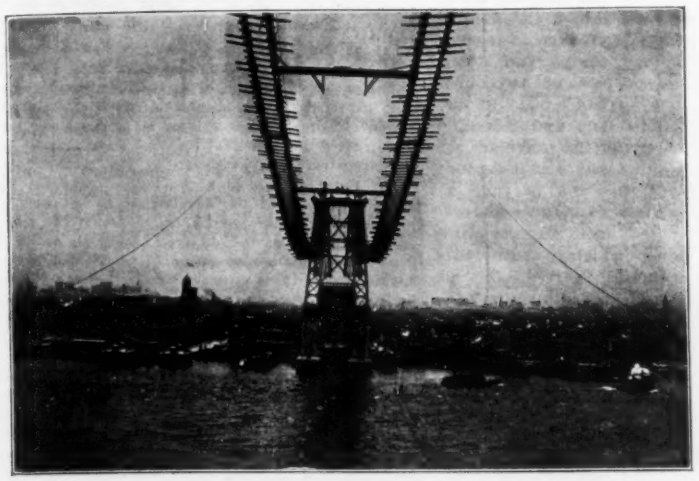


FIG. 4. VIEW OF MAIN SPAN OF FOOT BRIDGE FROM BELOW.

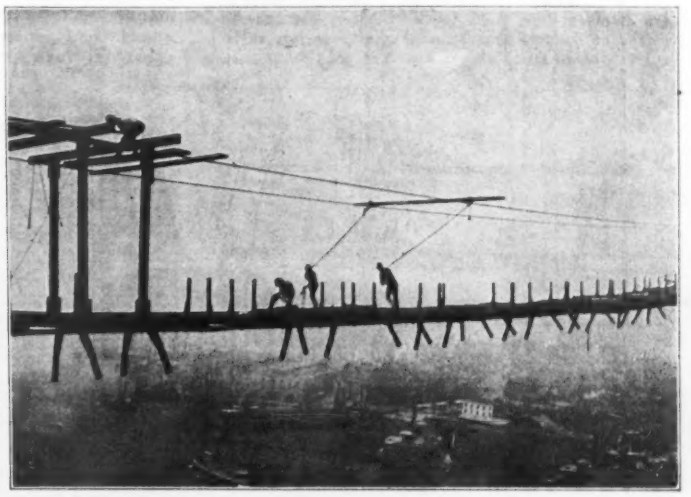


FIG. 5. VIEW SHOWING METHOD OF ERECTING UPPER DECK OF FOOT BRIDGE.

ERECTION OF THE SUPERSTRUCTURE.—The placing of the timber work was begun at each tower, and worked downward toward the center of the main span, and toward the anchorages on the land spans. Each piece was framed and marked as to its location in the structure before being hoisted from the ground. Two travelers for the main span were first erected, at each tower, and two for each land span. In each case a traveler ran on two cables by means of grooved wheels connected by an axle to which was suspended a platform large enough to accommodate four or five men. The cable bands, suspender rods and floor beams were attached to the cable by the men on the traveler. The traveler was allowed to run down the cable in advance of the work. The traveler is shown in Fig. 2. Another gang followed up the traveler and laid planks across the floor beams as fast as they were swung into place. Fig. 3 is a view from the traveler on the main span, looking back at the work just placed. In the main span the material was carried down from the towers by hand, but on the land span each bent was framed complete on the truss below and hoisted up and connected to the cables by the men on the travelers. It was necessary to keep the work on the two sides of the tower well balanced, so as not to cause the cables to slip over the saddles from undue loading in one span.

The travelers advanced toward the center of the main span simultaneously from each tower, so that the meeting point was at the center. When this point was reached the travelers were taken apart and carried back over the footwalk to the towers.

A view of the main span from below, at the level of the roadway in the tower, is shown in Fig. 4.

The land span travelers were run down to the anchorages, and taken apart there. Handrail posts were next bolted to the floor beams, and a ⅝-in. galvanized wire rope for a handrail was stretched along the full length of each footwalk.

Before commencing to erect the upper deck of the main span four addition 2¼-in. ropes were suspended. These ropes were drawn across the bridge from the Manhattan tower, the reel being placed at the foot of the tower. This pulling was done by an engine on the Brooklyn anchorage with a ⅝-in. plough-steel line, passing over the Brooklyn tower and running on the sheaves on top of the footbridge saddles. Each of the four ropes was hung just above one of the footbridge cables, and rested in the same saddle at the top of the tower. These ropes were suspended at a certain elevation so as to be just below the floor beams of the upper deck, and carry their proportion of the load of the bridge. In each land span they were drawn down and clamped to the other three ropes forming a cable.

The erection of the frame work for the upper deck was begun at the center of the main span and carried toward the towers. The material was run down on top of the cable by bridgemen who held each end with a line and ran along the footwalk with each piece, as shown in Fig. 5. When the posts, stringers and floor beams were in place, the 2 × 6-in. flooring was laid over the beams, beginning at the towers and working toward the center. The flooring on the land spans was similarly laid. Handrails of ⅝-in. galvanized wire rope were stretched on each side of every footwalk, and secured to the handrail posts with staples.

Half way between each anchorage and tower and at three points along the main span were erected frame towers about 12 ft. high. On these were supporting sheaves over which ran a traveling rope.

STORM CABLES.—The four 2¼-in. storm cables previously described, each about 1,700 ft. long, were delivered on reels at the foot of the Manhattan tower. The free end was taken to the top of the tower, passing up the land side, and crossing over the top toward the river on the sheaves on top of the footbridge saddles. The rope was now drawn across the footbridge in the same way as were the cables for the upper deck. They were laid across the lower deck beams and in such a manner that they could be easily pushed overboard. While in this position a suspender of ½-in. galvanized wire rope was fastened every 40 ft. The other end of the suspender was attached to the footbridge cables. The length of each had been regulated by previous calculations, so that when the storm cable became suspended by them it would hang in the form of a parabola.

When all the suspenders were properly connected the cable was lowered overboard by means of blocks and falls at numerous points until it was hung on the suspenders. The two ends were then pulled into each tower, and sockets placed upon them. Each was secured to one of the main posts of the tower and screwed up to the proper tension by means of long U-bolts. A view of the main span, with the storm cables and guys in place, is shown in Fig. 6. The footbridge was secured additionally by means of long guy ropes which ran from the main span down to the towers.

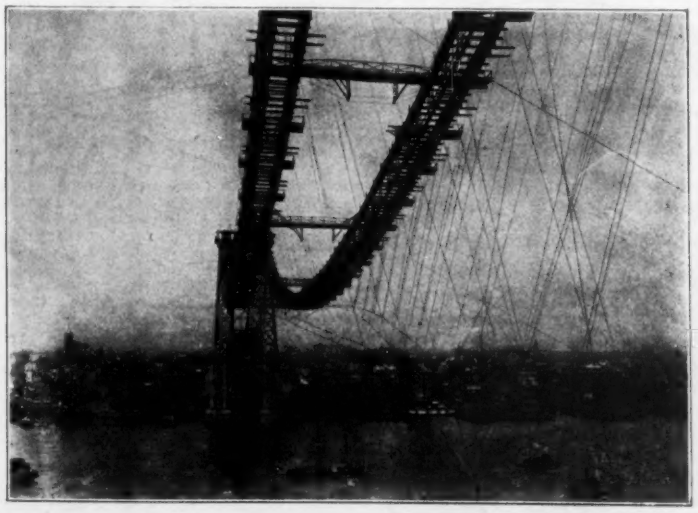


FIG. 6. VIEW SHOWING MAIN SPAN OF FOOT BRIDGE, WITH STORM CABLES AND GUYS IN PLACE.

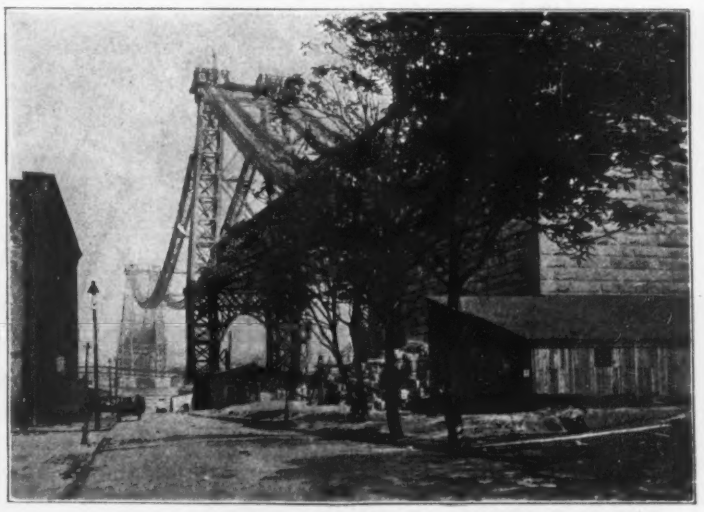


FIG. 7. VIEW OF COMPLETED FOOT BRIDGE FROM BROOKLYN ANCHORAGE.

Fig. 7 is a view of the completed footbridge as seen from Brooklyn, just back of the anchorage. When the structure was completed, observations were made to determine how near the bridge came to occupying the position for which it was finally intended. The result of the observations showed it to be within a very few inches of the calculated position, which was a great source of gratification to the engineers in charge, as it proved the correctness of the assumptions, the exactness of the intricate calculations involved, and the accuracy of the instrument work.

When the last wire in each main cable had been laid and the last strand adjusted, the usefulness of the upper deck of the footbridge was at an end. The whole of the upper deck work was then removed, the flooring being transferred to the lower deck and the other timber work being kept on the span, so as not to change the loading and consequently the position of the bridge. The upper cables were tied to the lower ones by long U-bolts, so as to make each carry a proportion of the load.

The work of putting on the cable bands and cable covering, and hanging the suspenders, can now be completed from the lower deck of the bridge.

The expectations of what the footbridge would accomplish have not been over-estimated, for it has permitted a saving of much time, made the work safer, and afforded a means of building the cables as nearly perfect as it is within human possibility to do. The erection of such a bridge may be usually considered a very hazardous occupation, but in this case not a single accident occurred.

Reference to cable making, except in explanation of the functions of the footbridge, has been purposely omitted in this paper, as that is a subject in itself.

THE NEW WESTINGHOUSE MANUFACTURING PLANT AND INDUSTRIAL TOWN AT TRAFFORD CITY, PA.

A new manufacturing plant and industrial town is being constructed by the various affiliated Westinghouse industries at a point on the Pennsylvania R. R., about 17 miles west of Pittsburg, Pa. This new community is known as Trafford City, and its object is to provide overflow factory sites for the Westinghouse machine, electric and air-brake works, which are now crowded for space, and also to provide homes for the workmen who will be employed in the new factories. The new plant and town is of interest from the fact that it has been laid out and is being built according to a pre-arranged plan settled upon and partly carried out before any of the land had been occupied.

INDUSTRIAL TOWN.—In laying out the industrial town, a plan of which is shown by Fig. 1, provision had to be made, first, for the factories to be located there, and, second, for the housing of the workmen in a comfortable and sanitary manner. The residence district was laid out on a hillside and generally level plateau, high enough above the factory site to render it free from the factory smoke and dust. It consists of two oblong areas, one about ½-mile long and 1-7 mile wide, and the other about ½-mile long and 1-5-mile wide, meeting in such a way as to form a reversed letter L, the corner of which is the northernmost part. These areas are laid out into about 800 building lots, having an average frontage of about 30 ft. and a depth of 100 ft., and into six park areas. There are water-works, a separate sewerage system, and paved streets. All this work was built before the town was opened to settlement, which was on June 7, 1902. The new town is connected with Pittsburg by the Pennsylvania R. R., and has a trolley line which loops through the principal streets and connects at Wilmerding, Pa., 2½ miles away, with the electric lines of the Pittsburg Railways Co. A steel viaduct connects the residence section with the Pennsylvania R. R. station. This viaduct is 1,100 ft. long, and carries the trolley line before mentioned.

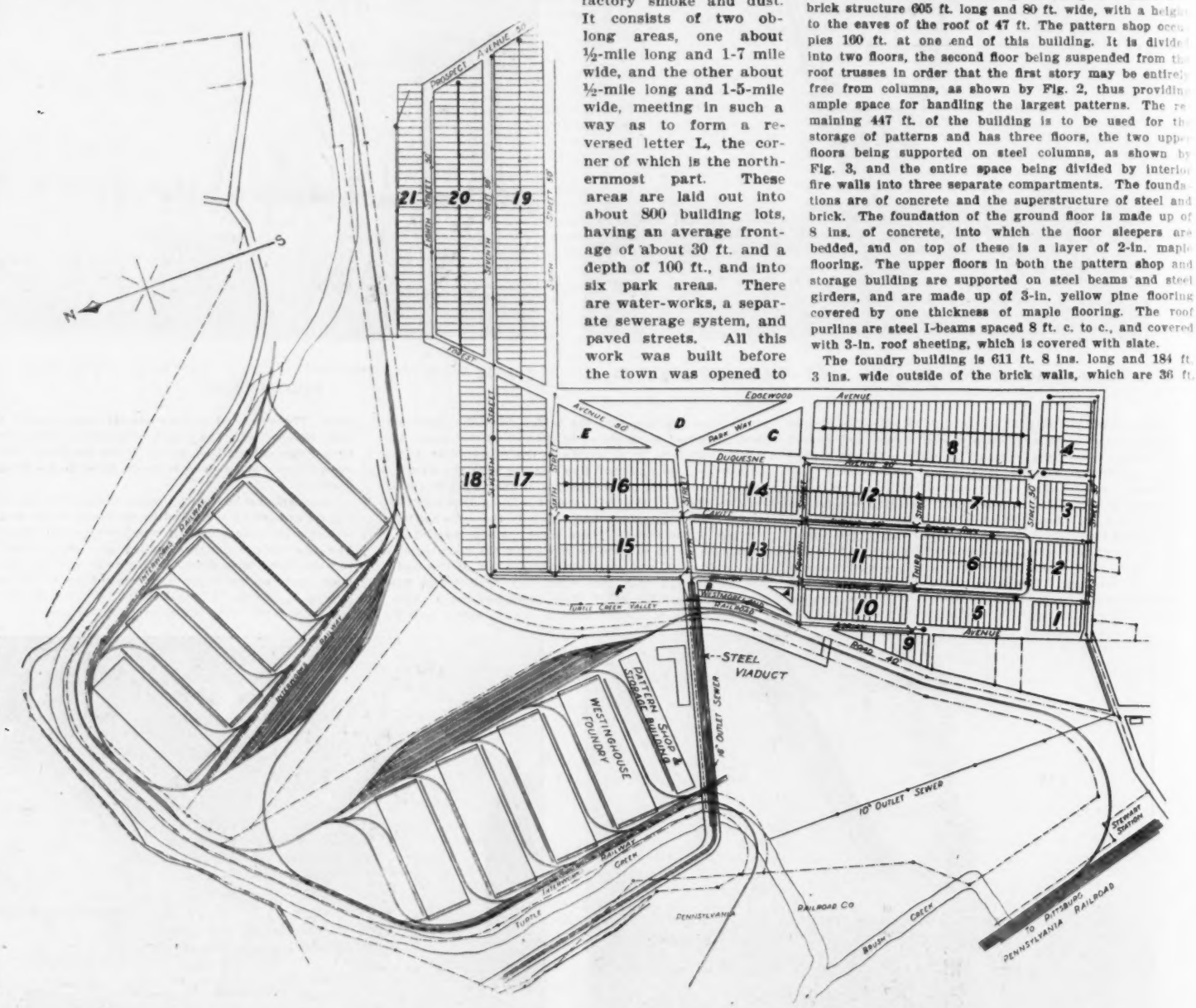


FIG. 1. PLAN OF MANUFACTURING PLANT AND INDUSTRIAL TOWN AT TRAFFORD CITY, PA.
The Westinghouse Companies, Pittsburg, Pa., Builders.

FACTORY SITES.—The factory sites, as is shown by Fig. 1, are located in a bend of Turtle Creek, about opposite the angle of the L formed by the residence districts. They provide for nine buildings, each about 200 × 800 ft. A system of yard tracks serves these buildings, the arrangement of the tracks being such that a track is provided alongside each building and another through the end of each building. These yard tracks connect with the main line of the Pennsylvania R. R. In addition to these yard tracks there is an interworks railway connecting these works with the works of the Westinghouse company at Wilmerding and East Pittsburg.

FACTORIES.—So far work has been begun on only two factory buildings at the new plant. These are a pattern shop and a foundry designed for the use of the Westinghouse Machine Co. The following description of these buildings has been furnished us by the Westinghouse Companies:

The pattern shop and storage building is a steel and brick structure 605 ft. long and 80 ft. wide, with a height to the eaves of the roof of 47 ft. The pattern shop occupies 160 ft. at one end of this building. It is divided into two floors, the second floor being suspended from the roof trusses in order that the first story may be entirely free from columns, as shown by Fig. 2, thus providing ample space for handling the largest patterns. The remaining 447 ft. of the building is to be used for the storage of patterns and has three floors, the two upper floors being supported on steel columns, as shown by Fig. 3, and the entire space being divided by interior fire walls into three separate compartments. The foundations are of concrete and the superstructure of steel and brick. The foundation of the ground floor is made up of 8 ins. of concrete, into which the floor sleepers are bedded, and on top of these is a layer of 2-in. maple flooring. The upper floors in both the pattern shop and storage building are supported on steel beams and steel girders, and are made up of 3-in. yellow pine flooring covered by one thickness of maple flooring. The roof purlins are steel I-beams spaced 8 ft. c. to c., and covered with 3-in. roof sheeting, which is covered with slate.

The foundry building is 611 ft. 8 ins. long and 184 ft. 3 ins. wide outside of the brick walls, which are 36 ft. high at the eaves and 80 ft. at the peak. As in the case of the pattern shop, the foundations are built of concrete and the superstructure of steel and brick. The foundry is divided transversely into three bays, the center bay being 80 ft. 3 ins. wide between centers of columns, runways being provided for traveling cranes of 80-ft. span and 150 tons lifting capacity. The cranes will be electrically driven. The two side bays are each 50 ft. 6 ins. wide, c. to c. of columns, and are provided with runways for traveling cranes of 47 ft. 2½ ins. span and 50 tons lifting capacity. At one side of the foundry building runways are provided for yard traveling cranes of 100-ft. span and a lifting capacity of 75 tons. The I-beam purlins are spaced 8 ft. c. to c. and are covered with 3-in. yellow pine roof sheeting. The roof is covered with slate.

At the middle of one of the side bays, where the cupolas

are located, is a charging floor about 50 ft. square, constructed entirely of steel. The melting equipment of the foundry will consist of two air furnaces, each having a capacity of 30 tons, and three cupolas capable of melting 18 tons per hour each. This will enable a casting weighing as much as 100 tons to be poured and the casting can afterwards be lifted out of the sand by one of the 150-ton traveling cranes. The air furnaces will be employed for the largest and most important castings, owing to the fact that they yield a superior quality of iron, and the cupolas will be employed for the ordinary classes of castings, and particularly small castings. The building will contain every modern convenience, making possible the easy and economical handling of all materials, and it is expected to produce such castings as those required for the largest size of steam engines now in existence, with

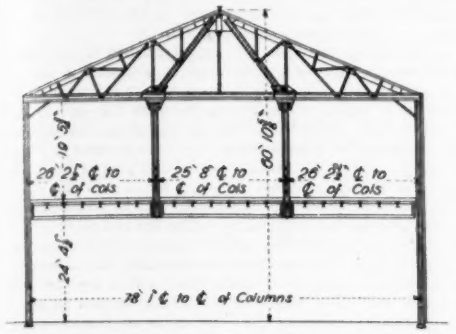


Fig. 2. Cross-Section Through Pattern Shop, Westinghouse Machine Co., Trafford City, Pa.

provision for possible increase in sizes for the future. Both buildings will be provided with automatic sprinklers for fire protection.

The buildings will be equipped throughout with lavatories and conveniences for the comfort of workmen. They will be heated by hot air, the foundry, pattern shop and pattern storage rooms to have minimum temperature of 50°, 60° and 35° F., respectively, in zero weather. Artificial light will be furnished by both arc and incandescent lamps. In order to insure plenty of light during the day, the windows are large, and both the foundry building and pattern shop are provided with skylights of large area. The plans for the buildings were prepared under the supervision of the Westinghouse Machine Co. The Security Investment Co., of Pittsburg, Pa., is the financial agent and general contractor for the entire works, and Messrs. James Stewart & Co., of St. Louis, Mo., are the Managers of Construction. The Real Estate Trust Co., of Pittsburg, Pa., successfully handled the extensive sale of city lots adjoining the new works.

THE ACTION OF WATER ON LEAD AND OTHER METALLIC OR METAL-LINED SERVICE PIPES.

The interesting studies of the action of water on certain metal service pipes carried on by the Massachusetts State Board of Health in 1897 and 1898* were continued in the two succeeding years, and are presented by Messrs. Harry W. Clark, Chemist, and Fred. B. Forbes, Assistant Chemist of the Board, in the report for 1900.

LEAD AND LEAD-LINED PIPE.

The report states that:

The results of the investigation up to the time of writing the report given in 1898 seemed to show that the cause of the taking of lead from the service pipes by the water of certain towns and cities was the presence of a considerable volume of free carbonic acid in the ground waters, which actively attacked lead, and further investigation has confirmed this conclusion. Many laboratory experiments during the past three years have shown that, while pure soft water, especially when containing some dissolved oxygen, attacks lead, and while the presence of coloring matter, free ammonia, nitrates and nitrites in soft water also causes considerable solvent action upon lead in laboratory experiments, yet, taking into consideration the results of our entire investigation, we find that in actual practice, with the conditions prevailing in the service pipes of a distribution system, a potable water in Massachusetts to have any dangerous lead-dissolving action must contain considerable free carbonic acid. It is not sufficient, however laboratory experiments may result, that a water be simply soft or comparatively free from mineral matters in solution alone to enable it to take a dangerous amount of lead into solution from service pipes in actual use. This is shown by results of analyses of samples of water collected from lead service pipes in towns supplied with surface water, most of these surface waters being softer than the average ground water of the state, but nevertheless not attacking lead to any great extent. Neither is the presence of an abundance of oxygen in the water in a distribution system, except when free carbonic acid is also present, any considerable factor in dissolving lead from service pipes in actual use, as is shown by the analyses of the samples from surface water supplies, although in laboratory experiments the opposite sometimes seems to be the case. There are some indications that the composition of the mineral contents of a ground water may influence slightly its action upon lead, and also that any considerable quantity of oxide of iron, separating from the water and depositing in the service pipes, has sometimes an appreciable action upon the lead. These are minor influences, however. It was shown also in the first report that the greater the hardness of the water as compared with its free carbonic acid, the less effect did this carbonic acid have upon lead, and further investigation has confirmed this.

The report contains a number of tables showing the results of analyses during the past two years. The most significant of these are the one showing the amount of lead found, grouped by ground and surface waters, and arranged under each group in accordance with the amount of lead found when the water is in ordinary use. These two tables in the report have here been combined in one. They also show the amount of lead after water had stood in the pipes over night, the average lengths and sizes of the services studied in each city, and the amounts of free canbonic acid and hardness.

*Reported at length in the annual report of the board for 1898, and abstracted in Engineering News for Jan. 4, 1900.

Lead in Samples of Ground and Surface Waters from Service Pipes in Various Massachusetts Cities and Towns, Arranged According to Average Amounts Found When Water Was in Ordinary Use.

	Lead (average).	Average length of pipe (ft.).	Average size of pipe (ins.).	Free CO_2. (Parts per 100,000.)	Hardness.	Locality.
			Ground Waters.			
In ordinary use	.1608	79	¾	3.287	3.5	Lowell, Cook and Hydraulic wells.
After standing in pipe	.2535					
In ordinary use	.1549	123	¾	4.148	2.6	Middleborough.
After standing in pipe	.6171					
In ordinary use	.0697	95	1	3.242	1.7	Attleborough.
After standing in pipe	.0905					
In ordinary use	.0432	179	¾	1.187	2.2	Newton.
After standing in pipe	.0908					
In ordinary use	.0400	43	¾	3.243	4.6	Hyde Park, old wells.
After standing in pipe	.3029					
In ordinary use	.0202	62	¾	1.301	1.5	Lowell, Boulevard wells.
After standing in pipe	.0861					
In ordinary use	.0187	265	¾	1.912	3.2	Grafton.
After standing in pipe	.0329					
In ordinary use	.0172	32	¾	2.773	2.9	Hyde Park, new wells.
After standing in pipe	.0329					
In ordinary use	.0101	98	¾	1.092	2.3	Wellesley.
After standing in pipe	.0219					
In ordinary use	.0100	76	¾	1.689	0.8	Webster.
After standing in pipe	.0286					
In ordinary use	.0091	112	¾	2,392	2.1	Needham.
After standing in pipe	.0269					
In ordinary use	.0082	230	¾	1.611	4.1	Dedham.
After standing in pipe	.0150					
In ordinary use	.0074	461	¾	1.149	4.7	Brookline.
After standing in pipe	.0197					
In ordinary use	.0057	127	¾	1.084	2.6	Bridgewater.
After standing in pipe	.0143					
In ordinary use	.0049	144	¾	1.529	2.9	North Attleborough.
After standing in pipe	.0226					
In ordinary use	.0048	39	1	2.411	6.3	Cohasset.
After standing in pipe	.0043					
			Surface Waters.			
In ordinary use	.0543	104	¾	1.100	1.6	Lawrence.
After standing in pipe	.0704					
In ordinary use	.0314	109	¾	0.152	0.3	Weymouth.
After standing in pipe	.1167					
In ordinary use	.0111	85	¾	1.105	1.3	Metropolitan supply
After standing in pipe	.0293					
In ordinary use	.0108	122	¾	0.119	1.0	Andover.
After standing in pipe	.0257					
In ordinary use	.0087	84	¾	0.121	2.3	Beverly.
After standing in pipe	.0147					
In ordinary use	.0025	58	¾	1.225	2.7	Cambridge.
After standing in pipe	.0064					

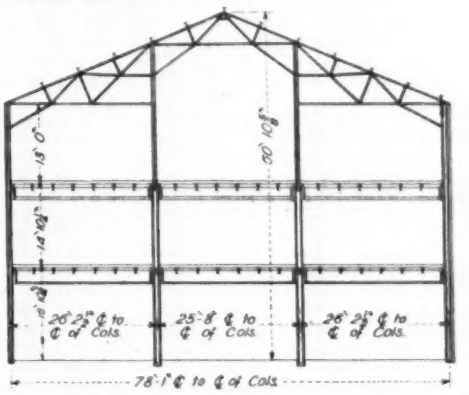


Fig. 3. Cross-Section Through Pattern Storage House, Westinghouse Machine Co., Trafford City, Pa.

In commenting on the figures for ground water supplies, the authors say:

The average length and size of the lead piping at each place has really very little to do with the amount of lead found in the samples of water that have remained in the pipe over night, providing only that the pipe is of sufficient size and length to hold a gallon of water, the usual amount collected for analysis. On the other hand, the length of the pipe may have considerable influence upon the amount of lead found in the samples taken during ordinary daytime use, as the longer the pipe, the greater is the period of time that the water is in contact with lead before it reaches the faucet. These variations in length thus have some influence upon the amount of lead found in the samples of water taken during daytime use and should be taken into account when comparing the average amount of lead found in samples from two water supplies having practically equal amounts of carbonic acid and being very similar in other respects.

Regarding the high amount of lead in the surface water supply at Lawrence, attention is called to the fact that this water

is in some respects similar to a ground water supply—that is, it is a surface water filtered through a slow sand filter in which nitrification takes place and the production of carbonic acid occurs.

GALVANIZED IRON, BRASS, BLACK TIN OR TIN-LINED PIPES.

Galvanized iron pipes may impart zinc, brass pipes may give up both zinc and copper, and tin or tin-lined pipes may yield tin to the water flowing through them. Brass and tin pipe are so little used that but few services of those materials could be tested. The amounts of zinc found, although running as high as 1.8469 parts per 100,000 for a sample of water from 4,000 ft. of galvanized iron pipe at West Berlin, was not considered "sufficient to have any effect upon the health of the consumers of the water." It was decided that copper and tin were not easily dissolved by the waters studied.

The general conclusions drawn by the authors are as follows:

In general, the results of the entire investigation seem to show that the use of lead service pipes, especially in connection with ground water supplies containing considerable free carbonic acid, should be avoided wherever possible, and that, if a cement-lined iron pipe is not employed, a tin or properly constructed tin-lined pipe with a considerable thickness of tin is the safest and best for general use. It is evident that brass pipe is acted upon but slightly by most of the waters examined, but copper salts are considered to be more harmful than salts of tin.

In conclusion, it may interest some to know what, in the opinion of the board, is a dangerous amount of lead in a drinking water. We therefore quote, as we did in our article two years ago, from the general report of the Board (p. xxxii.) for 1898, as follows:

While the quantity of lead dissolved may be small, and a single dose might not seriously harm the user of the water, the continued use of water containing lead is harmful, because lead is a cumulative poison. The exact amount of lead which may be taken into the system without producing harm is not definitely known and may vary with different people, but it is known that the continuous use of water containing quantities of lead as small as 0.05 parts per 100,000 or about 1-33 grain per gallon, has caused serious injury to health.

PROPOSED FURTHER DEVELOPMENT OF UNDERGROUND WATER SUPPLY FOR BROOKLYN.*

By I. M. de Varona, M. Am. Soc. C. E.†

The extent and importance of the underground supply on the south side of Long Island, and the exceptional purity of the water therefrom, are facts within the knowledge not only of engineers and geologists, but also of all those living in or at all familiar with that watershed. Wells sunk into the saturated sand and gravel constituted Brooklyn's earliest source of supply, and "prior to the introduction of Croton water in New York were also largely drawn upon for the use of the latter city." In fact, "about 1835 Mr. Hunt, of Baltimore, purchased hose and other appliances for the purpose of supplying New York city from the Brooklyn wells, the project being defeated, however, by legal process." (See p. 1 of the "Introductory to the History and Description of the Water Supply of the City of Brooklyn," by the writer.)

The capabilities of the underground supply have in past years been often discussed by the Brooklyn engineers, and various plans proposed to utilize it, as may be seen in the annual reports of the old department of city works and in the "History and Description of the Supply of the City of Brooklyn," already referred to. The delay in authorizing the extension of the water-works system eastward led, in the summer of 1882, when the present Mayor of Greater New York, Hon. Seth Low, was Mayor of Brooklyn, to a call for bids for an additional supply, as the result of which a contract was made with Messrs. Andrews & Co. for the driven-well stations at Springfield and Baiseleys, which were completed and put in operation in August, 1883. Since then, and in order to meet similar emergencies, other driven-well stations have been built under contracts for additional supply urgently required, until there are at present in the Ridgewood system alone 14 such stations, some of them with duplicate plants and with an approximately average daily capacity of over 45,000,000 gallons of water much safer and of far better quality than at present supplied to any other of our large cities. The disadvantages of our driven-well stations have been discussed in our reports. Among them mention may now be made of the large cost of maintenance, due to the multiplication of pumping stations, and to the frequent clogging of wells, and, hitherto, the alleged damage to crops, etc., from the lowering of the underground water level, which has formed the basis of numerous suits for extortionate claims against the city. This last objection, which has been the main reason until now influencing this department against the further development of plans to utilize the underground supply, has lost much of its force owing to the recent legal decision limiting the measure of damage to the loss in fee and rental value referred to in my last Quarterly Report, so that, with the incentive of possible heavy recoveries from the city thus largely eliminated, the extension of the underground system can now be much more safely adopted, especially if plans be devised to reduce the cost of installation and maintenance, and deserves full consideration, particularly in regard to the supply to be obtained from Suffolk county, to which further reference will be made.

After giving some consideration to the preparation of plans to utilize the underground supply, which would meet the above requirements, I would respectfully recommend the adoption on some experimental stations of the following plan, the main features of which are outlined in the annexed blue print (see engraving herewith—Ed.) under the designation of Plan B, and which may be briefly described thus:

At a given depth, to be determined by experiment, say from 3 to 6 ft. below mean high tide, a trench would be dug approximately at right lines to the direction seaward of the underground waters, and in this trench and surrounded on all sides by a layer, say, 6 ins. thick of broken stone or coarse gravel, will be laid terra cotta or concrete pipes, with open joints, leading to a central well and extending, say, half a mile on each side of the latter. The water from the saturated bed would find its way into the pipe through the annular spaces of the open joints, which would be proportioned so as to leave ample margin in case of clogging, and as the estimated rate of flow from the surrounding sand into the gravel would be but a small fraction of the velocity required to move sand of the size of anise seed, no danger of sand being washed into the pipe through the gravel can reasonably be apprehended. From the central well the water would be pumped and delivered into the conduit, and on either side of the suction pipe there will be movable flash boards or stop planks fitted into rabbets in the masonry, which would make it possible to regulate exactly the depth to which the level of the underground stream could be lowered, since the water delivered from the terra cotta pipes would enter the well and flow over the flash boards as shown by the arrows in the diagram. These movable flash boards would, furthermore, be used as weirs to determine the quantity of flow. It is apparent that by this means the lowering of the underground level is under easy and absolute control. As the length of the pipes is only about 2½ ft. the lowering of the underground level along the length of the pipe would be practically uniform. Furthermore, as the depth of the delivery pipe would be from 10 to 12 ft. below the average level of the underground water and from 13 to 15 ft. below the average surface of the ground, it would, before entering the well, be subjected to sufficient filtration to practically destroy all bacterial life. It may be interesting to add in this connection that we have not yet, from lack of time, made experiments to determine the number of bacteria in the ground in our watershed as we proceed below the surface. There is a scarcity of data on this subject. Figures reported in the Edinburgh "Medical Journal" for 1899, in the case therein referred to, show a rapid decrease, the numbers of bacteria per gramme being given as follows: At the surface, 1,680,000; 2 ft. below, 900,000; 4 ft. below, 25,000; 6 ft. below, 410.

In our watershed there is practically no difference in the water from wells above the blue clay differing 20 ft. or more in depth. The line of division, as far as our analyses show, lies, as might be expected, between the wells above and those below the blue clay, and also between wells east and west of Millburn, owing, no doubt, to the difference in surface pollution. No masonry will be required in the plan under discussion other than that of the central well, the pipes being simply laid in the trench, as already explained, and no driven wells are used. The cost, then, both of installation and maintenance, is a minimum, as will be shown hereafter. It may be stated that this method is a modification of the old "gallery" plan proposed in the early period of our water-works and recommended several years after, with some changes, by Chief Engineer Van Buren. For purposes of illustration and comparison, it has been assumed that the delivery pipes will extend half a mile on each side of the pumping station. These stations would be established, however, at intervals to be determined after further study, and so connected as to be operated from a central station, thus reducing largely the operating expenses under present methods. The saving in expense by the concentration of pumping stations, which, capitalized, would represent millions of dollars, led the writer years ago to advocate the consolidation of the stations on our line, as will be seen by referring to the Annual Report of the Department, but owing to reasons which it is needless now to detail, the plan was never completed or carried out. The details for the consolidation of the stations on the plan now discussed are under consideration, and will be pushed as rapidly as the available time will allow. There seems to be at present no reason to doubt the success of this all important feature of the proposed plan, which may furthermore be applied to existing stations on our line and particularly to those east of Millburn.

In the annexed blue print the sketch designated as Plan A represents a driven-well station under the plans now in operation on our system, which, in order to facilitate comparison, is assumed to be of the same length assumed for Plan B, i. e., half a mile on each side of the pump, and with double wells staggered and at intervals of 85 ft. driven to the depth of from 40 to 50 ft. The number and size of the wells and proportion of the sections are calculated, assuming the capabilities of the station under Plan A to be the same as under Plan B.

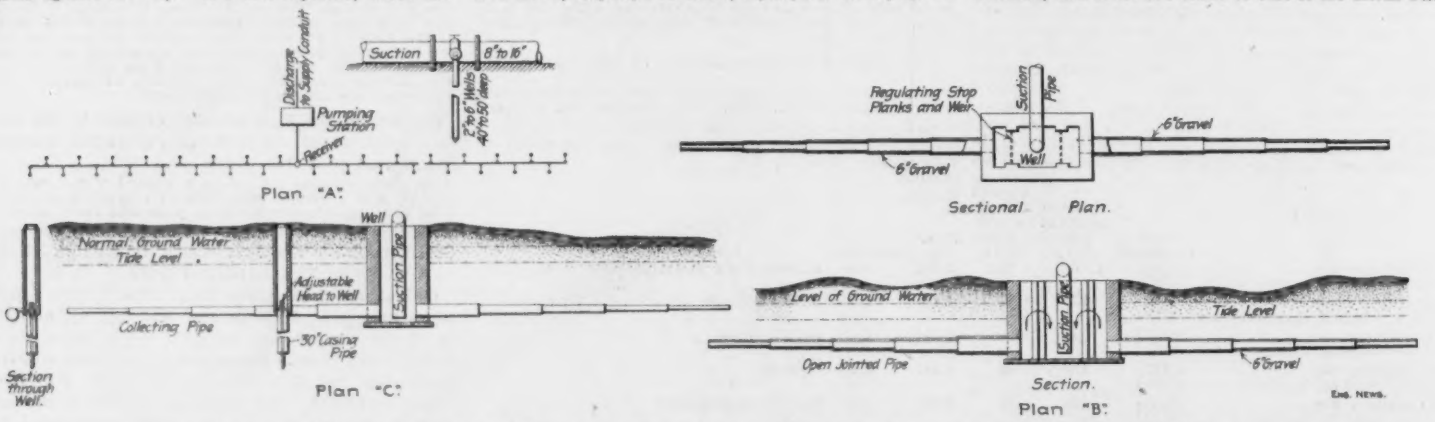
In the same blue print the sketch marked C illustrates the method suggested by Mr. John R. Freeman in his report, which you desired me to consider. In this case, however, as it would not be fair to compare the cost of the brick conduit, which forms part of the plan suggested by Mr. Freeman, with the delivery and suction pipes of Plans A and B, I have substituted a collecting pipe of the same size and dimensions used for Plan B. As in the other cases, it is assumed that the capacity of this station will be the same as that represented under the two other plans. Mr. Freeman claims that by this method the lowering of the underground stream may be regulated, that it will be more uniform than under the present driven-well system, and that the water would be sufficiently filtered to practically remove bacterial life. These claims are conceded, but Plan B has also these advantages, while the regulation of the lowering of the flow line is simpler, the lowering more uniform, there are ready methods of measuring the supply, and, more important than all, the cost is considerably less. Thus, on estimates based on the same prices for the same materials and work, the cost of the stations represented in the attached blue print, exclusive of pumps and buildings, are in round numbers as follows:

Plan C (suggested by Mr. Freeman), say.....$48,500
Plan A (present driven-well system), say..... 26,500
Plan B (as herein recommended), say 17,000

It is apparent, therefore, that the plan herein proposed would cost about one-third of the one suggested by Mr. Freeman, and about two-thirds of that of the driven-well stations, and has the additional advantage of entirely dispensing with driven wells and the expenses due to clogging, washing or repairing the same.

Even under the plan herein recommended there probably would be sufficient lowering of the underground water level to cause some damage to adjoining property and give rise to suits at law. It would be advisable, therefore, when establishing any stations for utilizing the underground supply to obtain releases from adjoining owners for damage which might be caused by the diversion of the underground water, and as under the present rulings of the courts the amounts that can be recovered for this diversion, as already explained, are comparatively small, it might be possible to secure these releases for comparatively small amounts, which would but slightly increase the cost of the supply.

In my communication of June 21, already referred to, I called attention to the alternative before us in regard to an additional supply from Suffolk county, and stated that while the Burr law, if sustained, prevented us from obtaining a surface supply, nothing, as I understood it, prevented us from utilizing the underground sources. Whatever the outcome of the attempt to test the Burr law may be, it is plain, therefore, that an underground supply, sufficient for many years to come and of exceptional quality, may be obtained from Suffolk county and under the plan herein recommended without serious reasonable objection.



DIFFERENT METHODS OF COLLECTING UNDERGROUND WATER FOR THE BROOKLYN WATER-WORKS.

Plan A. Typical Example of Present Driven Well System. Plan C. Modification of Method Formerly Suggested by Mr. John R. Freeman, M. Am. Soc. C. E.
Plan B. Mr. De Varona's Proposed Pipe Collecting System.

*From the Report of the New York Department of Water Supply, Gas and Electricity for the Quarter Ending June 30, 1902. The blue prints from which the illustrations were prepared were not reproduced in the report, as published in the "City Record" of Sept. 15, and were kindly furnished to this journal by Mr. de Varona.

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